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REPORTS OF THE
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
STATE OF NEW JERSEY

Division of Geology and Waters
HENRY B. KÜMMEL, *State Geologist*

BULLETIN 19

(Geologic Series)

Additional Bench Marks in Burlington, Camden, Mercer, Middlesex and Monmouth Counties

By

C. C. VERMEULE
Consulting Engineer

Published August, 1918.

Union Hill, N. J.
HUDSON PRINTING COMPANY
1918

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Introduction.

A list of bench marks in New Jersey was published in 1888 in Volume I of the Final Report Series of the State Geologist. With passing years many of these have been lost by the destruction or removal of the buildings on which they were placed. In 1916 a revised and enlarged list for northern New Jersey was printed as Bulletin 17 of the publications of this Department. The present list gives additional marks for several counties in the central part of the State. Its publication has been delayed a year in the hope that additional funds would be available to continue this work, particularly in Camden County and counties farther south. As this seems impracticable in the near future it is best to avoid further delay, in order that these results may reach engineers and others who wish to use them as soon as possible.

Report of C. C. Vermeule, Consulting Engineer.

Dr. H. B. Kummel,
State Geologist,
Trenton, N. J.

Sir:

I have to report as follows concerning the further prosecution of the work of revising primary levels and bench marks, which was undertaken in accordance with your instructions in September, 1916.

The following lines of levels were run:

1. **From Perth Amboy through Hightstown, Bordentown, Burlington and Mt. Holly to Moorestown and Camden.**
2. **From Burlington to Camden.**
3. **From Monmouth Junction through Freehold to Sea Girt, and thence along the sea shore to Highlands.**
4. **From Keyport to Freehold.**

In addition to these continuous lines, the bench marks of the U. S. Coast and Geodetic Survey were examined and new bench marks established from Sandy Hook to Keyport, and at Red Bank.

The results of the checks are given herewith: The line from Perth Amboy through Jamesburg to Monmouth Junction, 20.5 miles, checked within +.10 ft. From Perth Amboy through Jamesburg and Burlington to Mt. Holly, 50.2 miles, checked with a difference of —.46 ft. The line from Perth Amboy through Burlington and Mt. Holly to Merchantville, 64.2 miles, checked within +.13 ft. The line from Monmouth Junction through Freehold to Keyport, 30.5 miles, checked with a difference of +.02 ft. The line from Monmouth Junction through Freehold to Asbury Park, 39 miles, checked with a difference of +.03 ft. The line from Monmouth Junction through Sea Girt to Highlands, 51.4 miles, checked with a difference of +.32 ft. The line from Keyport to Freehold, 13.5 miles, checked with a difference of +.075 ft. The line from Keyport through Freehold and Sea Girt to Highlands, 47.9 miles, checked with a difference of +.33 ft. The line from Keyport through Freehold and Sea Girt and Asbury Park, 39 miles, checked with a difference of +.01 ft.

The lines leveled over aggregated 152.6 miles, but there were many short runs between bench marks which would add largely to this distance. The leveling was done by Mr. Loren P. Plummer, Jr.

Within the territory covered, the original bench marks numbered 43. Of these, 22 were recovered and verified, and 21 were found missing. The recovered bench marks, together with new bench marks established, afford a total of 291 effective bench marks within the territory, as the result of the recent work, as against 22 old bench marks found intact.

From Sandy Hook to Perth Amboy, the U. S. Coast and Geodetic Survey has run in all three lines of primary levels. The adopted elevation in the attached list varies slightly from these several elevations for the reason that it was decided not to change the datum which was used in our original system of primary levels. The differences are small, but I include herewith a list of the various elevations for convenient reference. In this list the number in the first column is the same as the number attached to the bench mark in question in the final list. In the last column is given the elevations adopted in the final list, and the other columns show the various elevations given in the several reports of the Coast and Geodetic Survey.

No. of Bench Mark.	Location.	Date of Levels. 1881.	1886.	1914.	Adopted Elevation.
1.	Atlantic Highlands............	......	....	13.658	13.77

ATLANTIC COUNTY.

SOMERS POINT. **Eleva. 26.16 ft.**

Elevation of underground mark, 21.535 feet. This monument (No. 11) is placed on the brow of the hill in front of the old Somers homestead, a brick building on the shore road, just south of the highway bridge over the railroad, at Somers Point. It is set in the center line of the road which runs to the west and is in the produced line of the curb along the northerly side of the street running down to the railroad depot. In 1887, the bearing to the southeast corner of Somers homestead was north 5° west, and the distance 75 feet; the distance northerly, measured along the shore road to the center of the railroad track was about 160.5 feet. (Note:—In changing the grade of the road in 1916, the stone was slightly disturbed laterally, but the above elevation applies to its new position. The monument is now 75 feet 2 inches from the southeast corner of Somers homestead; 69 feet measured northerly from the corner of the most westerly brick fence post of the Hayday property, and 43 feet 3 inches from the most westerly post of porch of house at the northeast corner of the forks.) The top of the monument is close to the new surface of the road.

SOMERS POINT. **Eleva. 25.11 ft.**

A cross on the outer corner, and at the base of a square red brick post, on the northwest end of the sixth step above the sidewalk, at the entrance on Station Avenue to the Hayday dwelling. The house is on the south side of the avenue at its junction with Main Street or Shore Road, and the property is diagonally opposite the old Somers homestead.

SOMERS POINT. **Eleva. 26.63 ft.**

A cross on the outer corner at the south end of east abutment of George Street bridge over the railroad, near the old Somers homestead at Main Street and Station Avenue. The cross is 2.6 feet below the bridge floor and about 1.5 feet south of south truss.

SOMERS POINT. **Eleva. 35.30 ft.**

A cross on the outer corner at the northeast end of blue stone door sill of front entrance to the City Hall on Main Street or Shore Road.

SOMERS POINT. **Eleva. 34.30 ft.**

A cross immediately below the hinge of the northerly door at the northeast end of cement step of double door entrance on the east face, and at the northeast corner of Somers Point public school. The door enters the lower portion of the building which is located on the northwest corner of First Street and New York Avenue.

CAPE MAY COUNTY.

The granite bench mark established in 1885 at the Sea Isle light house was moved in 1899. Elevations of the re-located monument and also of some other points near, are given below.

SEA ISLE CITY. **Eleva. 9.151 ft.**

This granite monument is set 14.92 feet northeast from the easterly corner of the oil house which stands northwest of the light house.

SEA ISLE CITY. **Eleva. 9.616 ft.**

A cross cut on the southwest or left end of granite door sill of oil house, which stands at northwest side of the light house.

SEA ISLE CITY. **Eleva. 10.5**
A mark on foundation at northeast side, 4 feet northwest of eas most corner of light house.

I submit herewith a list of the bench marks verified, and new bench marks established.

Respectfully submitted,

C. C. VERMEULE,
Consulting Engine

February 14, 1917.

List of Bench Marks.

BURLINGTON COUNTY.

BEVERLY. **Eleva. 35.71 ft.**

A cross on the outer corner at the north end of door sill of entrance, on the west face of Beverly Presbyterian Church on Warren Street near Farnum.

BEVERLY. **Eleva. 32.65 ft.**

A cross on the outer edge at the northerly end of blue stone door sill of Cooper Street entrance to Mechanics National Bank. The cross is immediately below the hinge of the left door.

BEVERLY. **Eleva. 36.22 ft.**

A cross on the south end of door sill of the most southerly entrance on the east face of the public school, a red brick building on Laurel Street near Oak.

BORDENTOWN. **Eleva. 65.78 ft.**

A cross at the foot of the stairway and at the galvanized iron newel post, on the concrete base of water tower, about one mile northeast of the Pennsylvania Railroad station, along the Camden and Amboy branch.

BORDENTOWN. **Eleva. 46.77 ft.**

A cross on the north end of the most northerly basement window sill of window on the west face of a red brick structure in the yard of the Bordentown Military Academy. The building is the most westerly one on the grounds.

BORDENTOWN. **Eleva. 24.17 ft.**

A triangle cut on coping stone at the east end of the south abutment of railroad bridge over roadway, just north of Bordentown station.

BORDENTOWN. **Eleva. 17.00 ft.**

A cross on the outer corner at the north end of northeast concrete abutment of P. R. R. bridge over stream near, and southwest of the station. The cross is on the girder seat and is 15 ft. from the girder.

BORDENTOWN. **Eleva. 57.52 ft.**

A cross on the inner corner, at the north end of brown stone door sill of the most northerly entrance, on the east face of Episcopal Church on the west side of Prince Street just north of Church Street. The door enters a wing of the building, and is back from the street.

BORDENTOWN. **Eleva. 57.11 ft.**

A cross on the outer edge at the north end of door sill of most southerly entrance, on the west face of First Baptist Church on the corner of Church and Prince Streets.

BURLINGTON. **Eleva. 12.12 ft.**

A cross on the outer edge at the east end of second granite step from bottom of the most easterly entrance, on the Broad Street face of Baptist Church, at the corner of Broad and Stacey Streets.

BURLINGTON. **Eleva. 13.62 ft.**

A cross on the base course of and on the left as you enter the Mechanics National Bank, opposite the P. R. R. station. The cross is directly under a bronze tablet reading "Mechanics National Bank."

BURLINGTON. **Eleva. 16.67 ft.**
On the white sandstone water table, and 4.3 feet east of east edge of Broad Street entrance to the Post Office. The point is on the outer edge and directly below west edge of window.

BURLINGTON. **Eleva. 16.90 ft.**
A cross on the outer corner at the north end of door sill of most northerly (rear) entrance on the east face of Episcopal Church on Broad Street.

DEACON. **Eleva. 61.64 ft.**
A cross on the center of cement cap of east parapet of red brick arch highway bridge, over a small stream about one mile southeast of the P. R. R. station, and on the easterly side of the track.

DEACON. **Eleva. 80.45 ft.**
On the water-table at southwest corner of brick school house, on east side of turnpike, three-eighths of a mile southeast of Deacon station.

DEACON. **Eleva. 57.77 ft.**
A copper bolt in marble slab on the northerly end of easterly parapet of P. R. R. culvert, about one mile southeast of Deacon station.

DEACON. **Eleva. 76.67 ft.**
A cross on the center of concrete cap of west parapet of red brick arch highway culvert about 300 yards southerly from the P. R. R. station and east of the track.

DELANCO. **Eleva. 15.27 ft.**
A cross on the south end of the southernmost basement window sill of window on the east face of brick school house at the corner of Hickory and Walnut Streets.

DELANCO. **Eleva. 8.57 ft.**
A cross on the southeast corner of a large stone on the east end of north stone pier of P. R. R. draw-bridge over Rancocas Creek. The cross is 6.5 ft. from the rail, and is on the seat supporting the draw.

EDGEWATER PARK. **Eleva. 26.99 ft.**
A cross on the northwest corner of a large stone and on the level of the girder seat at the north end of west abutment of P. R. R. bridge over highway at the station. The cross is 8 ft. from the rail, and immediately at the face of a stone retaining wall.

EDGEWATER PARK. **Eleva. 28.81 ft.**
A cross on the outer edge at the east end of bottom concrete step of

HAINESPORT. **Eleva. 9.89 ft.**
A cross on the northwest corner of stone on which rests the east end of the north truss of highway bridge over the "South Branch of Rancocas" at J. D. Johnson Company's factory.

HAINESPORT. **Eleva. 12.11 ft.**
A cross on a cap stone of the northeast wing wall of east abutment of highway bridge over the "South Branch of Rancocas." The cross is immediately at the southwest corner of a brick building of the J. D. Johnson works.

HAINESPORT. **Eleva. 30.53 ft.**
A cross on the east edge at the south end of a cement sidewalk, on the east side of highway just east of the P. R. R. station. The cross is immediately below the southwest corner of a rough stone fence post, and is about 25 feet, measured northerly, from the railroad tracks.

HARTFORD. **Eleva. 68.60 ft.**
A cross on the southwest corner of a large stone on the southerly end of east abutment of P. R. R. bridge over Mt. Holly Pike, about ¾ mile west of station. The cross is on the level of the girder seat.

HARTFORD. **Eleva. 26.83 ft.**
A cross on the southwest corner of the fourth stone step from the top of a number of steps forming the wing wall at the south end of east abutment of P. R. R. bridge over Parkers Creek, about one-half mile east of station. The cross is on the layer of stones that forms the girder seat.

KINKORA. **Eleva. 9.74 ft.**
A cross on the southwest corner of concrete base of signal on the northerly side of P. R. R. tracks and 250 feet westerly from the station.

KINKORA. **Eleva. 11.53 ft.**
A cross on the southwest corner at the south end of east stone abutment of P. R. R. bridge, over stream about one-half mile west of station. The cross is on the girder seat and 8 feet from the girder.

MAPLE SHADE. **Eleva. 21.51 ft.**
A cross on the southeast corner of the top stone step on the wing wall at the south end of west abutment of P. R. R. stone arch bridge over "South Branch of Pensauken Creek," about one-half mile west of station.

MAPLE SHADE. **Eleva. 40.57 ft.**
A cross on the south end of door sill of entrance, on the east face, to brick school building, about 200 yards south of the railroad track, just east of the P. R. R. station.

MAPLE SHADE. **Eleva. 23.20 ft.**
A cross on the southwest corner at the west end of north concrete parapet of P. R. R. bridge over "North Branch of Pensauken," about one mile east of station (or ¼ mile west of Lenola station). The cross is slightly above and 6 feet from the rail.

MASONVILLE. **Eleva. 46.10 ft.**
A cross on the northwest corner of concrete base of signal, about 100 yards west of P. R. R. station, and on the north side of the track.

MASONVILLE. **Eleva. 19.46 ft.**
A cross on the southwest corner of large stone and on the level of the girder seat, at the south end of east abutment of P. R. R. bridge over Mason's Creek, about ¾ mile east of station.

MOORESTOWN. **Eleva. 62.63 ft.**
A copper bolt on the west end of brown stone door sill of the entrance to waiting room, on the north face of West Moorestown station.

MOORESTOWN. **Eleva. 71.40 ft.**
A cross on the outer corner at the westerly end of door sill of boys' entrance on the northerly face of High School. The building is on North Church Street, about 200 yards southerly from the West Moorestown railroad station. The cross is the same elevation as the stone base course of the structure.

MOORESTOWN. **Eleva. 75.45 ft.**
A cross on the white sandstone water-table, 3.2 ft. above the ground, and in the center of the front of "Relief Fire Engine" house, on the west side of Chester Avenue, about 200 feet southerly from the P. R. R. tracks.

MOORESTOWN. **Eleva. 79.44 ft.**
A copper bolt on the west end of door sill of the waiting room entrance to Stanwick Avenue station.

MOUNT HOLLY. **Eleva. 12.74 ft.**
A cross on the outer edge at the east end of door sill of most westerly entrance to "Union Fire House No. 2," on the south side of Mill Street.

MOUNT HOLLY. **Eleva. 16.89 ft.**
On northwest corner of door sill of National Bank, on northeast corner of Main and Mill Streets.

MOUNT HOLLY. **Eleva. 32.11 ft.**
A cross on the outer corner at the easterly end of a large brown stone window sill, on the north face of the Post Office. The building is of brown stone construction, and the window is the first from the northwest corner of the structure.

MOUNT HOLLY. **Eleva. 35.60 ft.**
A point on the outer edge at the northerly end of marble door sill of Main Street entrance to Mt. Holly National Bank, near the "Friends Meeting House." The point is on the higher portion of the sill next to wooden casing.

MOUNT HOLLY. **Eleva. 39.78 ft.**
A point on the outer corner at the extreme southerly end of blue stone door sill of Main Street entrance to "New Washington Hotel" near the Court House.

MOUNT HOLLY. **Eleva. 42.96 ft.**
On the northwest corner of marble door sill of main entrance to

PALMYRA. **Eleva. 23.44 ft.**
A cross on the westerly end of brown stone window sill of the most westerly basement window on the north face of Palmyra Public School. The structure is of red brick and is at the forks of the road, about 200 yards southerly from the P. R. R. station.

PALMYRA. **Eleva. 14.10 ft.**
A cross on the southeast corner of a large stone on the southerly end of northeast abutment of P. R. R. bridge over Pensauken Creek, about one mile westerly from the station. The cross is on the level of the girder seat and is 4 feet from the girder.

RIVERSIDE. **Eleva. 22.70 ft.**
On the outer corner at the westerly end of door sill of the main entrance to the offices of the Keystone Watch Case Co. The building is just above the P. R. R. station on the westerly side of the track.

RIVERSIDE. **Eleva. 24.60 ft.**
A cross on the outer corner at the easterly end of door sill of Scott Street entrance to Riverside National Bank, about 200 ft. westerly from Pavilion Avenue.

RIVERSIDE. **Eleva. 25.05 ft.**
A cross on the outer corner at the westerly end of door sill of Scott Street entrance to Riverside Turncemeinde, a red brick building about 100 yards westerly from Pavilion Avenue.

RIVERSIDE. **Eleva. 19.78 ft.**
A cross on the outer corner at the easterly end of brown stone door sill of corner entrance on Scott Street to W. F. Taubel, Inc. Co.'s knitting mill and offices. The structure built of yellow brick, is on the southerly side of the railroad track at the east corner of Scott Street and Fairview Avenue.

RIVERTON. **Eleva. 7.49 ft.**
A cross on the northeast corner of concrete block at the southerly end of westerly abutment of P. R. R. bridge over stream about ¼ mile northeast of station. The cross is about 4½ feet below the rail.

RIVERTON. **Eleva. 21.14 ft.**
A cross on the outer corner at the northeast end of cement door sill of rear entrance, on the northwest face of store of J. S. Collins & Son, Inc., opposite the P. R. R. station and on the southerly side of the track.

RIVERTON. **Eleva. 15.34 ft.**
A cross on the outer edge at the southwest end of granite door sill of Fourth Street entrance to Public School, a brick building on the north corner of Howard Avenue and Fourth Street.

RIVERTON. **Eleva. 16.83 ft.**
A cross on the northerly end of door sill of tower entrance on Main Street to Christ Church, at the north corner of Fourth and Main Streets.

ROEBLING. **Eleva. 27.77 ft.**
A cross on the step and at the base of an iron post at the corner entrance to the M. W. Stern building at the P. R. R. station. The cross is a trifle above the sidewalk and the building is but a few feet southerly from the railroad track.

ROEBLING. **Eleva. 50.85 ft.**
A cross on the outer corner, at the southerly end of white sandstone step of entrance on the westerly face of Greek Catholic Church. The building is about 200 yards westerly from the P. R. R. station and about 100 yards southeast of the track, facing the trolley line.

ROEBLING. **Eleva. 45.70 f**
A cross on the outer corner at the north end of door sill of entranc on the east face of Roebling Public School, on the south side of tl Roebling-Florence highway.

STEVENS. **Eleva. 23.97 f**
A cross on the southwest corner of concrete base of signal, about 2(yards easterly from the P. R. R. station and on the north side of tl track.

CAMDEN COUNTY.

CAMDEN. **Eleva. 20.22 f**
A cross on the northeast end of basement window sill and near tl stone bearing date of 1913, at the northwest corner of N. G. N. armory on Wright Avenue, about 400 yards northeast of the City Hal

CAMDEN. **Eleva. 30.44 f**
A cross on the outer corner at the northerly end of granite door si Haddon Avenue entrance to City Hall.

CAMDEN. **Eleva. 24.75 f**
A cross on the outer corner at the north end of sandstone door sill most northerly entrance on 6th Street to the First M. E. Church, opposi Cooper Hospital.

CAMDEN. **Eleva. 19.09 f**
A cross on the outer edge and six inches above sidewalk at the nor end of granite step of entrance to P. R. R. station and outbound electr trains, on Broadway.

CAMDEN. **Eleva. 28.42 f**
A cross on granite base supporting columns and on the extreme rig of Federal Street entrance to Y. M. C. A. near Broadway. The cro is 3 feet above the sidewalk and on the face of the building.

CAMDEN. **Eleva. 29.90 f**
A cross on outer corner, at the west end of large stone slab and do sill of most westerly entrance on Federal Street to Court House.

CAMDEN. **Eleva. 29.94 f**

FISH HOUSE. **Eleva. 15.97 ft.**
A cross on the level of the girder seat and on the southeast corner of large stone on the east end of north abutment of P. R. R. bridge over roadway just below the station. The cross is 7 feet from the girder.

MERCHANTVILLE. **Eleva. 37.44 ft.**
A cross on the northwest corner of concrete base of signal at crossing about one-half mile west of Wellwood station, and on the southerly side of the P. R. R. track.

MERCHANTVILLE. **Eleva. 80.50 ft.**
A copper bolt at the west end of marble door sill, main entrance to ladies' waiting room of P. R. R. station.

MERCHANTVILLE. **Eleva. 80.46 ft.**
On the west end of marble door sill (close by corner of brick work) of the east front door of railroad station.

MERCHANTVILLE. **Eleva. 90.56 ft.**
A cross on the outer edge at the south end of cement door sill of the most southerly entrance to public school on Center Street, about three blocks south of the P. R. R. station.

MERCHANTVILLE. **Eleva. 94.07 ft.**
A cross on the outer corner at the east end of door sill of most westerly entrance on West Maple Avenue to Trinity M. E. Church at Chapel Avenue.

MERCHANTVILLE. **Eleva. 76.61 ft.**
A cross on the southeast corner of granite stone and on the level of the girder seat, at the south end of west abutment of P. R. R. bridge over the Delaware River R. R., about one-half mile east of station.

MORRIS. **Eleva. 8.36 ft.**
A cross on the outer corner at the southerly end of door sill of entrance to boiler room on the easterly face of Camden water works.

MERCER COUNTY.

HIGHTSTOWN. **Eleva. 89.67 ft.**
A cross on the outer corner and on the level of the girder seat, at the westerly end of southerly concrete abutment of P. R. R. bridge over Millstone River about one mile northeast of station. The cross is 13 feet from the girder.

HIGHTSTOWN. **Eleva. 97.11 ft.**
A copper bolt surrounded by a square cut on the south end of east abutment of P. R. R. bridge over Main Street. The bolt is about 3 feet below the rail and 4 feet from the girder.

HIGHTSTOWN. **Eleva. 92.00 ft.**
A cross on the outer corner and on the layer of stones forming the girder seat at the south end of west abutment of P. R. R. bridge over Main Street. The cross is 18 feet from the girder.

HIGHTSTOWN. **Eleva. 112.13 ft.**
A cross on the east end of door sill of most westerly entrance on Stockton Street to First Methodist Church at the corner of Church Street.

HIGHTSTOWN. **Eleva. 87.78 ft.**
A cross on the south end of brown stone door sill of corner entrance to Cunningham's drug store on the southwest corner of Main and Stockton Streets.

HIGHTSTOWN. **Eleva. 86.36 ft.**
A cross on the outer corner at the south end of granite door sill of Main Street entrance to First National Bank, on the west side of Main, about 100 feet north of Stockton Street.

HIGHTSTOWN. **Eleva. 116.87 ft.**
A cross on the southerly end of basement window sill of the third window from the southwest corner on the westerly face of public school. The structure is about 350 yards southwest of the P. R. R. station, on the Hightstown-Windsor road.

HIGHTSTOWN. **Eleva. 118.10 ft.**
A cross on the southwest corner of concrete base of water supply pipe for engines, at the junction of Amboy Division of P. R. R. and the Pemberton-Hightstown R. R., about one mile southwest of the station. The structure is between the tracks, and about 50 yards below the tower house.

ROBBINSVILLE. **Eleva. 87.34 ft.**
A cross on the outer corner of the second stone step of four steps forming the southerly end of west wall of P. R. R. arch culvert over Miry Run, about ¾ mile northeast of the station. The cross is about eleven feet below the rail.

ROBBINSVILLE. **Eleva. 91.89 ft.**
A cross on the center of cap of southerly parapet of concrete highway bridge over Miry Run, about ¾ mile northeast of the station and near the P. R. R. track. The cross is directly over the center of opening for the stream.

ROBBINSVILLE. **Eleva. 125.24 ft.**
A cross on the outer edge at the northerly end of bottom cement step of the most northerly entrance on the northeast face of hotel, opposite the P. R. R. station. The building is on the westerly side of Robbinsville-Hamilton Square highway.

ROBBINSVILLE. **Eleva. 125.47 ft.**
A cross on the inner corner at the northwest end, and directly below the edge of a window, of top concrete step at entrance to office of the Lumber Co. at the railroad station. The building is on the westerly

YARDVILLE. **Eleva. 56.88 ft.**
A cross .5 foot below the rail and one foot from the southeast end of easterly concrete abutment of P. R. R. bridge over Back Creek, about 1¼ miles northeast of the station.

YARDVILLE. **Eleva. 59.15 ft.**
A cross on the outer corner and at the base of a wooden post, on the southerly end of cement floor of porch of Anderson Bros.' building. The structure is of wood and is on the westerly side of the Yardville-Crosswicks road about 75 yards southerly from the P. R. R. crossing.

YARDVILLE. **Eleva. 56.59 ft.**
A cross on the outer edge at the northerly end of door sill of upstairs and office entrance, on the northeast face of Zee Zee Rubber Co.'s building. The structure is on the southwest side of the Yardville-Crosswicks highway, and sets back about 200 feet southwest of the road.

YARDVILLE. **Eleva. 35.33 ft.**
A cross on the outer edge of the girder seat and 4½ feet from the girder, on the west end of south concrete abutment of Penn. R. R. bridge over Crosswicks Creek, about ½ mile southwest of station.

MIDDLESEX COUNTY.

CRANBURY. **Eleva. 98.39 ft.**
A cross on the outer corner and on the level of the girder seat, at the east end of south abutment of P. R. R. bridge over Cranbury Brook, about ½ mile northeast of the station.

CRANBURY. **Eleva. 118.80 ft.**
A cross on the northwest corner of concrete base of iron pole opposite the P. R. R. station, and on the easterly side of the track.

CRANBURY. **Eleva. 120.56 ft.**
A cross at the face of the building and on the northerly end of first step at the entrance on easterly face of a small stucco building about 200 yards southerly from the P. R. R. station and 200 feet west of the track.

DAYTON. **Eleva. 101.88 ft.**
A cross on the northwest corner of the most westerly concrete pier supporting an iron column at the southerly end of the Trenton and New Brunswick Electric Railroad bridge over the P. R. R., about one mile west of the station.

DAYTON. **Eleva. 112.12 ft.**
A cross on the northerly end of cement door sill of main entrance to school house on the easterly side of the Dayton-Deans highway, about ¼ mile northerly from the P. R. R. station. The building is of concrete block and frame construction.

DAYTON. **Eleva. 104.87 ft.**
A cross on the southwest corner of concrete base of signal west of the crossing and on the south side of the P. R. R. tracks at the station.

DAYTON. **Eleva. 127.44 ft.**
A cross on the northwest corner of concrete base of iron pole on the south side of the P. R. R. track and west of an overhead highway bridge about two miles easterly from the station.

ERNSTON. **Eleva. 93.58 ft.**
A cross on the girder seat and 10 feet west of west rail at the westerly end of southerly concrete abutment of P. R. R. bridge over highway at the station.

ERNSTON. **Eleva. 49.08 ft.**
A cross on the outer corner of a large stone, and on the level of bed plate of girder at the easterly end of southerly abutment of P. R. R. bridge over highway, about 1½ miles southwest of station, or at Brown's station.

HELMETTA. **Eleva. 44.07 ft.**
A cross on the center of window sill of the first window on the left of entrance on the northerly face of Helmetta public school. The sill is 3.3 feet above the ground, and the building is in the northeast section of the city, near and on the southerly side of the P. R. R. tracks.

HELMETTA. **Eleva. 40.39 ft.**
A cross on the northerly end of window sill of window on the easterly face and at the northeast corner of boiler house of Geo. W. Helme Co.'s plant, east of the P. R. R. station. The structure is south of the track and highway.

HELMETTA. **Eleva. 41.62 ft.**
A square cut on the door sill of brick store on the southerly side of highway at Geo. W. Helme Co.'s plant, near the P. R. R. station. This is a railroad bench mark.

HELMETTA. **Eleva. 41.93 ft.**
A cross on the westerly end of basement window sill of window on the southerly face, and at the southwest corner of Catholic Church, about 200 yards southerly from the P. R. R. station and east of the track and highway.

HOFFMAN. **Eleva. 62.81 ft.**
A copper bolt, on the top stone step at the west end of north abutment of P. R. R. bridge, over Manalapan Brook about ¾ mile northwest of the station. The bridge is about 100 yards south of a crossing.

HOFFMAN. **Eleva. 81.33 ft.**
A cross on the southwest corner of concrete base of hand signal, near the crossing and south of the P. R. R. track at Hoffman station.

JAMESBURG. **Eleva. 115.66 ft.**
A cross of 0.5 foot below and 5½ feet south of the rail, on the south end of west abutment of P. R. R. bridge over highway about ¾ mile west of Jamesburg Junction toward Monmouth Junction.

JAMESBURG. **Eleva. 50.94 ft.**
A cross cut on the west end of the stone door sill of the First National Bank.

JAMESBURG. **Eleva. 53.09 ft.**
A cross on the level of the girder seat, 6½ feet from the bridge railing and on the outer corner at the east end of south abutment of P. R. R. bridge over Manalapan Brook, about ¾ mile southeast of Lower Jamesburg station.

MORGAN. U. S. C. S. -15. **Eleva. 9.71 ft.**
A square cut on the top of the southwestern pier of the Central Railroad of New Jersey drawbridge over Cheesequake Creek. The cut is not deep and is in the concrete between the wooden beams.

MORGAN. U. S. C. S. -16. **Eleva. 5.98 ft.**
A square cut on the top of the northeastern pier of the Central Railroad of New Jersey drawbridge over Cheesequake Creek. It is a railroad bench mark, and is cut deep into the lower pier. There is one of these cuts on each pier of this bridge.

OLD BRIDGE. **Eleva. 6.90 ft.**
A cross on the level of the girder seat, 8 feet from the rail and on the outer corner of a large stone at the southerly end of easterly abutment of P. R. R. bridge over stream, about 300 yards southwest of Runyon station, or 1⅝ miles northeast of Old Bridge.

OLD BRIDGE. **Eleva. 5.63 ft.**
A cross on the level of the girder seat and at the northwest end of southerly concrete abutment of P. R. R. bridge over Deep Run, about ¾ mile northeast of the station.

OLD BRIDGE. **Eleva. 12.29 ft.**
A cross on the northwest end of cement door sill of entrance to boiler room on the southerly face and at the southeast corner of Old Bridge Brick and Tile Co.'s building, on the northerly side of the P. R. R. tracks and northeast of the station.

OLD BRIDGE. **Eleva. 7.54 ft.**
A cross on the level of the girder, 12 feet from the rail and on the outer edge near the northwest end of southerly abutment of concrete bridge carrying P. R. R. over South River, northeast of station.

OLD BRIDGE. **Eleva. 13.51 ft.**
On the left hand side of the corner entrance and on the level of the cement floor of porch of stucco dwelling immediately back of the P. R. R. station on the main street.

OLD BRIDGE. **Eleva. 18.97 ft.**
A cross on the cement walk, 12 feet out from the northeast corner and 37 feet measured along the face from the southeast corner of Old Bridge Hotel, at the forks of the road southwest of the Railroad station and north of the track.

PROSPECT PLAINS. **Eleva. 112.02 ft.**
Top and at the west end of 48 inch cast iron pipe culvert under railroad and highway, about 350 yards northeast of the railroad station. The point is 2.3 feet below a wall built around the pipe and at the side of the road. The pipe projects 2 feet beyond the wall.

PROSPECT PLAINS. **Eleva. 125.69 ft.**
A cross 7 feet from the west end and 38 feet east of east rail of railroad track on the cement curb in front of hotel at the crossing near the station.

PROSPECT PLAINS. **Eleva. 124.11 ft.**
A cross on the southerly end of cement door sill of entrance, on the west face of the Oakland garage, on the easterly side of railroad track, between the crossing and the station.

PROSPECT PLAINS. **Eleva. 126.71 ft.**
A square cut in a brown stone monument 20 feet southwest of the railroad station and 13 feet from the rail. This is a railroad bench mark.

SOUTH AMBOY. **Eleva. 19.82 ft.**
A cross on the northeast corner of cap stone on the wall at the east end of south abutment of Central Railroad bridge over Raritan Bay. The cross is slightly below the rail and 7 feet east.

SOUTH AMBOY. **Eleva. 28.11 ft.**
A cross on the southerly end of door sill of entrance to waiting room, on the westerly face of station at the junction of the Camden and Amboy Division of Pennsylvania and Central Railroads.

SOUTH AMBOY. **Eleva. 29.91 ft.**
A cross on the level of the girder seat and on the outer corner at the southerly end of easterly concrete abutment of P. R. R. bridge over highway, about 200 yards west of the P. R. R. station.

SOUTH AMBOY. **Eleva. 27.86 ft.**
A cross on the northeast corner of concrete cap at the northerly end of bridge pier carrying the P. R. R. yard tracks over the Central Railroad, about 300 yards southerly from the Pennsylvania station. The cross is 3 feet below the yard tracks.

SOUTH AMBOY. **Eleva. 81.33 ft.**
A square cut on a slight ledge on the east face of west stone abutment of bridge carrying the Raritan River R. R. over the P. R. R., about one mile southwest of the Pennsylvania station. The ledge is 2½ feet above the Pennsylvania tracks and 21 feet from the northerly end of the abutment. "B. M. No. 64" is cut on the stone above the projection.

SPOTSWOOD. **Eleva 27.32 ft.**
A cross on the northwest corner of concrete base of bell signal on the westerly side of the Pennsylvania Railroad track at the crossing, about 100 yards southwest of East Spotswood station, or about 1¼ miles

SPOTSWOOD. **Eleva. 27.34 ft.**
A square cut in a brown stone monument 20 feet westerly from the railroad station and 20 feet southeast of the rail. This is a railroad bench mark.

TRACEY. **Eleva. 83.69 ft.**
A cross on the southwest corner of concrete base, supporting pivot for a switch-rod angle on the southerly side of the Pennsylvania Railroad track, 150 feet easterly from the station and at the signal tower. The elevation of the rail at the station is 84.3 feet.

MONMOUTH COUNTY.

ALLAIRE. **Eleva. 63.21 ft.**
A cross .7 foot out from the building, on the easterly edge of cement walk leading to concrete switch-house on the north side of the railroad track, about 200 yards west of the station.

ALLAIRE. **Eleva. 48.73 ft.**
A cross on the outer corner, at the easterly end of southwest parapet of arch culvert under the railroad just west of the station.

ALLAIRE. **Eleva. 52.00 ft.**
Top of marble monument projecting 1½ feet above the ground, and marking a property corner on the easterly side of the raceway, about 25 yards in front of and southwest of the railroad station.

ALLENHURST. **Eleva. 14.06 ft.**
A cross on the south end of door sill of most northerly entrance, on the west face of the Atlantic Coast Electric Co.'s car barn, at the southeast corner of Main Street and Elberon Avenue. The entrance is a single door and is near the northwest corner of the building.

ALLENHURST. **Eleva. 17.85 ft.**
A cross on the south end of door sill of most southerly entrance, on the west face of the railroad station. The structure is east of the track and the door enters the express company's office.

ALLENWOOD. **Eleva. 63.70 ft.**
A cross 6 inches from the building, on the westerly edge of cement walk leading to concrete switch-house, at the crossing, just west of the railroad station.

ALLENWOOD. **Eleva. 68.93 ft.**
A cross on the westerly end of blue stone window sill of window on the southerly face and at the southwest corner of brick store building, at the forks of the road, near and west of the railroad station. The sill is 5 feet above the ground.

ALLENWOOD. **Eleva. 63.72 ft.**
A cross near the westerly end of cement door sill of easternmost double door entrance, on the southwest face of the blacksmith shop, a red brick structure at the forks of the road, easterly from the railroad station. The floor of building is the same level.

ALLENWOOD. **Eleva. 65.00 ft.**
A cross on the northeast corner of concrete base of bell signal, at the crossing, easterly from the railroad station.

ALLENWOOD. **Eleva. 80.43 ft.**
A cross on the northeast corner of concrete base of signal on the north side of the railroad, about 1½ miles east of the station. The signal is just east of mile post 31-2.

ASBURY PARK. **Eleva. 25.26 ft.**
A cross on the outer corner at the east end of top step at the girls' entrance to school building on Main Street, near Wesley Lake, in Ocean Grove.

ASBURY PARK. **Eleva. 19.64 ft.**
A cross on the west end of door sill of main entrance on Lake Avenue to Armory of Company H, 3rd Regiment, N. G. N. J.

ASBURY PARK. **Eleva. 24.34 ft.**
A cross on the outer corner, at the west end of brown stone door sill of entrance to Sea Coast Building, on the corner of Bond Street and Mattison Avenue.

ASBURY PARK. **Eleva. 25.05 ft.**
A cross on the outer corner at the west end of cement floor of alcove at the boys' entrance to public school, corner of Somerfield Avenue and Bond Street. The entrance is on the south face of the building.

ASBURY PARK. **Eleva. 24.58 ft.**
A cross on the outer corner at the east end of blue stone door sill of rear entrance, on the southerly face of the First M. E. Church, corner of First and Grand Avenues.

ASBURY PARK. **Eleva. 24.69 ft.**
A cross on the outer corner at the south end of first step below the door sill of Grand Avenue entrance to Trinity P. E. Church on the corner of Grand and Asbury Avenues.

ASBURY PARK. **Eleva. 25.90 ft.**
A cross on the outer corner at the extreme east end of top granite step of entrance to alcove of Post Office, corner of Somerfield Avenue and Main Street. The cross is immediately below the southwest corner of marble base supporting column of easternmost arch.

ASBURY PARK. **Eleva. 21.53 ft.**
A cross on the extreme outer corner at the north end of granite sill of entrance on Main Street to the Asbury Park and Ocean Grove Bank, opposite the railroad station. The cross is immediately below the southwest corner of the base-stone of column on the left as you enter the building.

ATLANTIC HIGHLANDS. U. S. C. S. -1. **Eleva. 13.77 ft.**
A red metal disc in the stone door step on the north side of Antonides

BELMAR. **Eleva. 23.57 ft.**
A cross next to the door jamb, at the south end of a large brown sandstone step at the main entrance to school building, on the corner of F Street and 12th Avenue.

BELMAR. **Eleva. 17.24 ft.**
A cross on the outer edge at the south end of door sill of entrance, on the west face of the railroad station.

BELMAR. **Eleva. 20.12 ft.**
A cross on the outer edge at the east end of top granite step and sill of entrance to the Coast Gas Co.'s Building on 9th Avenue, about 100 yards east of the railroad.

BELMAR. **Eleva. 16.86 ft.**
A cross on the southwest end of door sill of corner entrance to the First National Bank on the southeast corner of F Street and 9th Avenue.

BRADEVELT. **Eleva. 162.77 ft.**
A cross on the level of the truss-seat and on the northeast corner at the north end of west concrete abutment of steel highway bridge over railroad just south of the station.

BRADEVELT. **Eleva. 161.93 ft.**
A cross on the east end of brownstone door sill and step of the most westerly entrance on the south face of the Reformed Dutch Church.

BRADLEY BEACH. **Eleva. 26.12 ft.**
A cross 5 inches from the east edge and near the center of bluestone cap, on the south pier supporting iron post of roof over driveway, at entrance, on the east face of the railroad station.

BRADLEY BEACH. **Eleva. 24.81 ft.**
A cross on the west end of door sill of most westerly entrance, on the south face of Borough Hall, a brick structure on north side of the park at the railroad station.

BRADLEY BEACH. **Eleva. 23.61 ft.**
A cross on the extreme right and on the level of the bottom step, at the base of brick support of arch of Bringley Avenue entrance to public school, east of the railroad station. The cross measures 7.5 feet from a point projected below the keystone of the arch.

BRADLEY BEACH. **Eleva. 23.59 ft.**
A cross at the face of the building and on the south end of granite sill and step of tower entrance, on the west face of Catholic Church, 2 blocks east of the railroad station on Bringley Avenue.

DEAL BEACH. **Eleva. 32.68 ft.**
A cross on the north end of door sill of northerly entrance, on the west face of the railroad station, east of the track.

DEAL BEACH. **Eleva. 30.33 ft.**
A cross on the center of cement window sill of most westerly window on the north face of the N. J. Water and Light Co.'s power house on the east side of the railroad, about ¾ mile north of the station.

ELBERON. **Eleva. 37.39 ft.**
A cross on the north end or door sill of most southerly entrance on the west face of the railroad station, east of the track.

ENGLISHTOWN. **Eleva. 71.64 ft.**
A cross on the corner at the westerly end of southerly concrete wall of small highway bridge over brook about 200 feet northeast of the railroad track on the Englishtown-Bergen Mills road. The highway crosses the track about ¼ mile northwest of the station.

ENGLISHTOWN. Eleva. 71.86 ft.

A cross 2.6 feet above the crest of the spillway and one foot out from the post of bridge railing, at the easterly end of southerly concrete abutment of steel highway bridge over stream, at the old mill on Main Street. The overflow of a lake is at the bridge.

ENGLISHTOWN. Eleva. 72.97 ft.

A cross on the outer corner at the north end of concrete slab forming the top step of 3 steps at the main entrance to Sanford Memorial M. E. Church, on the west side of Main Street.

ENGLISHTOWN. Eleva. 72.67 ft.

A cross on the outer edge at the southerly end of door sill of corner entrance to First National Bank on the southwest corner of Main and Water Streets.

ENGLISHTOWN. Eleva. 72.43 ft.

A cross on the extreme outer corner at the south end of top step of Main Street entrance to W. E. Mount Co.'s store opposite Water Street.

ENGLISHTOWN. Eleva. 79.72 ft.

A cross on the southeast corner of concrete base of signal, north of the track and on the west side of the crossing at the railroad station.

FAIRFIELD. Eleva. 117.77 ft.

A cross on the northeast corner of concrete base of bell signal for trains at the railroad station. The cross is 6½ feet southerly from the rail and the signal is about 50 feet southeast of the station. The elevation of the rail at the crossing is 118.1.

FARMINGDALE. Eleva. 74.32 ft.

A cross on the southeast corner of concrete base of railroad signal, on the southerly side of the track and 200 ft. southeast of a crossing, about ¾ mile northwest of the station along the P. R. R.

FARMINGDALE. Eleva. 71.77 ft.

A cross on the level of the girder seat and on the outer corner at the northerly end of southeast concrete abutment of P. R. R. bridge over Marsh Bog Brook, about ¾ mile northwest of the station.

FARMINGDALE. Eleva. 74.15 ft.

A cross on the southeast edge of cement walk leading to concrete switch-house, at the crossing, about ¼ mile northwest of the station along the Pennsylvania Railroad. The cross is at the entrance and 6 inches below the sill.

FARMINGDALE. **Eleva. 44.04 ft.**
A cross on the level of the girder seat and on the southeast corner of a large stone at the southerly end of westerly abutment of P. R. R. bridge over a stream about one mile southeast of the station. The cross is 8 feet from the girder.

FREEHOLD. **Eleva. 186.23 ft.**
A cross cut 2½ inches south of the intersection of the three joints formed by the three most southerly stones in the south corner of the large triangular base of the Monmouth Battle Field Monument. The cross is 2½ inches south of the north apex of the stone which abuts on its south sides against the octagonal gun pedestal, which is built at the south corner of the triangular base.

FREEHOLD. **Eleva. 181.69 ft.**
A square cut on the northwest end of brownstone door sill of entrance to ladies' waiting room, on the northeast face of the P. R. R. station.

FREEHOLD. **Eleva. 176.70 ft.**
A cross 8 feet from the southwest corner, on the base stone of the Laird building. The structure is on the northerly side of West Main Street, about 100 yards northeast of the P. R. R., and the cross is on the left of the center entrance.

FREEHOLD. **Eleva. 178.49 ft.**
A cross on the westerly end of brownstone door sill of entrance to First National Bank, on the northerly side of West Main Street, about 125 yards northeast of the P. R. R. crossing.

FREEHOLD. **Eleva. 177.74 ft.**
A cross cut on the east end of stone door sill of the Sheriff's office, being the most easterly of two doors in the middle of the front of Monmouth County Court House.

FREEHOLD. **Eleva. 146.17 ft.**
A cross on the southwest corner of fourth stone step below the girder seat at the southerly end of easterly abutment of P. R. R. bridge over roadway, about ½ mile easterly from the station. The date 1890 is on the face of the stone.

FREEHOLD. **Eleva. 127.20 ft.**
A copper bolt in the stone cap at the westerly end of southerly parapet of P. R. R. stone arch bridge over stream, about 1¼ miles southeast of the station. The bridge is about 150 yards easterly from a highway crossing.

GALILEE. (SEE MONMOUTH BEACH.)

HIGHLANDS. U. S. C. S. -2. **Eleva. 13.77 ft.**
A red metal disc in the top of the eastern pier of the railroad drawbridge.

(Note: This bench mark is on the southeast wing wall at the east end of bridge, near Highland Beach Station.)

HIGHLANDS. U. S. C. S. -3. **Eleva. 202.41 ft.**
This bench mark is a mark on top surface of a heavy granite post near Navesink light house. The post is deeply imbedded and its top projects about 1½ feet above the surface of the ground. It is 13 meters (42.6 feet) south of the southernmost tower of Navesink Highlands light house.

HIGHLANDS. U. S. C. S. -4. (Primary mark D.) **Eleva. 207.53 ft.**
This bench mark is the bottom surface of a square cavity (about one inch square) cut on a sloping ledge at southeast corner of base of southernmost light house tower at Navesink Highlands light.

HOLLYWOOD. (SEE WEST END.)

HOWELL. **Eleva. 124.21 ft.**
A cross on the northwest corner of concrete pier supporting the northwest wooden post of framework holding a water tank just east of the railroad station. The cross is 8 feet southerly from the rail, and a trifle below. The elevation of the rail at the crossing nearby is 124.3 feet.

KEYPORT. U. S. C. S. -5. **Eleva. 36.30 ft.**
A red metal disc in the east end of the door step on the north side of the station of the Central Railroad of New Jersey

KEYPORT. U. S. C. S. -6. **Eleva. 22.91 ft.**
The center of a cross cut in the east corner of the stone door sill of the First National Bank, or Keyport Banking Co. The structure is on the south side of Front Street, east of Broad.

KEYPORT. U. S. C. S. -7. **Eleva. 42.15 ft.**
A cross cut on a brick in the front or north side of the Aberdeen Hotel. The cross is about 1.5 feet west of the western door of the hotel and about 2.5 feet above the porch floor.

KEYPORT. **Eleva. 21.61 ft.**
A cross on the north end of bluestone door sill of Broad Street entrance to People's National Bank on the west side of Broad, about 200 feet south of Front Street.

KEYPORT. **Eleva. 26.60 ft.**
Top edge and corner of marble cornerstone at the northwest corner of the Raritan Guard Public Library, on the east side of Broad, about one block south of Front Street.

KEYPORT. **Eleva. 35.39 ft.**
A cross on the west end of door sill of entrance on the south face and near the southwest corner of public school at Broad and Mott Streets.

LAKE COMO. **Eleva. 20.95 ft.**
A cross on the outer corner at the north end of door sill of most southerly entrance on the west face of the railroad station.

LONG BRANCH. (LONG BRANCH CITY.) **Eleva. 11.27 ft.**

LONG BRANCH. (LONG BRANCH CITY.) **Eleva. 14.93 ft.**
A cross on the northwest corner of second stone step from the top on the north end of east abutment of Eatontown branch of Central Railroad over Long Branch Avenue. The bridge is on the curve of the track southwest of East Long Branch station, and the stone is the first below the girder seat.

LORILLARD. U. S. C. S. -8. **Eleva. 13.55 ft.**
A red metal disc in the top of the northwest pier of the small masonry bridge, about 200 meters (about 650 feet) east of the railroad station.

MANASQUAN. **Eleva. 19.37 ft.**
A cross on the outer edge at the easterly end of granite door sill and step of entrance to the Manasquan National Bank on Main Street, just east of South Street.

MANASQUAN. **Eleva. 19.66 ft.**
A cross on the cement floor of porch, immediately below the east corner, of the Osborn Hotel, at the corner of South and Main Streets. The floor of the porch and the sidewalk are on the same level.

MANASQUAN. **Eleva. 24.93 ft.**
A cross on the outer corner at the south end of door sill of most southerly entrance, on the west face of Presbyterian Church at the corner of South Street and Virginia Avenue.

MANASQUAN. **Eleva. 20.23 ft.**
A cross on the outer corner at the south end of cement step or sill of entrance to the Osborn Hardware store, a frame building on the west side of Broad Street, about 200 feet north of Main Street.

MARLBORO. **Eleva. 114.37 ft.**
A cross 6 inches from the outer corner of the stone on which rests the south end of east girder, near the east end of south abutment of New Jersey Central Railroad bridge, over stream about ¾ mile north of the station.

MARLBORO. **Eleva. 150.31 ft.**
A cross on the west end of basement window sill of the most westerly window on the south face of the Monmouth County Farmers' Exchange, a brick structure east of the railroad track and on the north side of the highway, just north of the station.

MARLBORO. **Eleva. 155.18 ft.**
A cross at the door casing on the west end of cement step and sill of entrance to the office of Abbott Worldley Co., a small brick building west of the track and at the crossing just north of the railroad station.

MATAWAN. **Eleva. 54.56 ft.**
A cross on the outer corner at the northeast end of door sill of upstairs entrance to the Gehlhaus Building, a brick structure on the southeast side of Main, at the corner of Little Street. The entrance is the first southerly from Little Street.

MATAWAN. **Eleva. 58.41 ft.**
A cross, 3.5 feet above ground, on the northeast end of brownstone window sill of northernmost window on the Main Street face of M. E. Church near Little Street.

MATAWAN. **Eleva. 56.17 ft.**
On the south (outer) corner of polished granite base stone of the southwestern pillar at entrance to the Farmers and Merchants National Bank, on the westerly side of Main Street.

MATAWAN. **Eleva. 35.91 ft.**
A cross on the south end of stone door sill of Episcopal Church on Main Street.

MATAWAN. **Eleva. 63.91 ft.**
A cross on the northeast end of the northeasternmost basement window sill on the southeast face of the Matawan High School, a brick building on the southwest side of Jackson Street, corner of Broad.

MONMOUTH BEACH. **Eleva. 9.17 ft.**
A cross on the south end of door sill of the most southerly entrance, on the west face of Monmouth Beach station of the New Jersey Central Railroad.

MONMOUTH BEACH. **Eleva. 8.04 ft.**
A cross on the southwest corner of concrete pier supporting the southwest wooden post of roof over platform at the Galilee station of the New Jersey Central Railroad. The pier is 24 feet from the south face of the station building.

MORGANVILLE. **Eleva. 98.52 ft.**
Top of iron pipe at the northwest end of culvert under highway about ⅝ mile southwest of the railroad station. The road crosses the track at the station.

MORGANVILLE. **Eleva. 102.30 ft.**
A cross on the topmost point and center of cement cap of the northernmost brick parapet of iron pipe culvert under highway, about ⅝ mile southwest of the railroad station. The road crosses the track at the station.

MORGANVILLE. **Eleva. 110.94 ft.**
A cross 7 feet above ground on the east end of cement door sill of most westerly entrance, on the north face of the R. V. C. Co.'s factory, on the easterly side of the track about ¼ mile north of the railroad station. The building is of red brick and is the largest of the plant.

MORGANVILLE. **Eleva. 136.27 ft.**
A cross on a foundation stone projecting beyond the east face of the west brick pier supporting frame of overhead highway bridge over railroad, ⅛ mile south of the station. The cross is 3.3 feet below the top and 2 feet from the north end of the pier.

NEW MONMOUTH. (NORTH LONG BRANCH.) **Eleva. 14.82 ft.**
A cross on the south end of door sill of the second entrance from the northwest corner and on the west face of the New Jersey Central Rail-

OCEAN GROVE. (SEE ASBURY PARK.)

PORT MONMOUTH. U. S. C. S. -9. **Eleva. 14.11 ft.**
A red metal disc set in the brick wall of a house which is south of the track and on the east side of the road crossing the track near the station. The bench mark is in the northwest corner of the cellar wall.

RED BANK. **Eleva. 45.77 ft.**
A cross cut on the south end of front door sill of the old First National Bank Building on Broad Street.

RED BANK. **Eleva. 44.25 ft.**
A cross on the outer edge at the north end of door step and sill of entrance to No. 40 Broad Street, occupied by the Red Bank Register. The building is on the west side of Broad, about 50 feet north of White Street.

RED BANK. **Eleva. 43.73 ft.**
On the extreme outer corner at the south end of granite step of Broad Street entrance to the Red Bank Trust Co., a marble structure on the east side of Broad Street, just north of Monmouth Avenue. The point is 6 feet south of the south door hinge and .6 feet above the sidewalk.

RED BANK. **Eleva. 43.09 ft.**
A cross cut on northeast corner of lower stone step of Monmouth Avenue entrance of M. E. Church, on the corner of Broad Street.

RED BANK. **Eleva. 41.08 ft.**
On the outer corner at the west end of bluestone door sill of upstairs entrance to Navesink Lodge No. 39, I. O. O. F., a yellow brick structure of three stories on the north side of Monmouth Avenue, about 200 feet west of Broad Street.

RED BANK. **Eleva. 40.80 ft.**
On the outer corner, at the extreme west end, and 6 feet west of the center of entrance, of marble base stone of Patterson Building, a one-story structure used as the Post Office. The building is on the north side of Monmouth Avenue, about 100 yards west of Broad Street.

RED BANK. **Eleva. 43.56 ft.**
A cross on the west end of bluestone door sill of driveway entrance, at the northeast corner of St. James Catholic Church, on Broad Street south of Monmouth Avenue. The entrance is under the porch, which extends across the driveway.

SANDY HOOK. U. S. C. S. -10. **Eleva. 8.56 ft.**
A bench mark of the Ordnance Department near the office building of the Sandy Hook proving grounds and about 60 meters (197 feet) northwest of a small water tank which is north of and across the railroad tracks from the office building. The bench mark is a copper bolt in the top of a granite post set in the ground and surrounded by cement.

SANDY HOOK. U. S. C. S. -11. **Eleva. 19.53 ft.**
This bench mark is a cross on the head of a copper bolt driven into the wall of the main light house, at Sandy Hook. The main light house is an octagonal tower, resting upon a circular foundation of unhewn stones. This foundation projects on all sides about 8 inches, beyond the base of the tower, so as to form a sloping ledge. The copper bolt is a few inches westward of the northwest angle, and 9¼ inches above the ledge.

SANDY HOOK. -12. **Eleva. 12.45 ft.**
A cross cut in the top of an iron bolt set in cement about 3 meters (10 feet) northeast of the northeast corner of the Army Engineer building near the wharf.
(This is a U. S. E. bench mark.)

SANDY HOOK. U. S. C. S. -13. Eleva. 10.76 ft.
A marble post about 4 feet long, the upper part dressed and the letters U. S. C. S. carved in the upper surface; in the center of the face there is a small cavity, about half an inch in dimensions. This mark is on the western slope of the high ridge at Sandy Hook, just east of the New Jersey Southern Railroad wharf. It is below the crest of the ridge, sheltered by vegetation, and 375 feet west of the western corner of the round house of the railroad.

SEA BRIGHT. Eleva. 9.93 ft.
A cross on the outer corner at the south end of top step at the most southerly entrance, on the east face of M. E. Church on the corner of Ocean Avenue and Church Street. The cross is at the entrance to alcove.

SEA BRIGHT. Eleva. 6.31 ft.
A cross on the outer edge and six inches from the north end of brown stone step at entrance to alcove of First National Bank on the west side of Ocean Avenue, two doors north of River Street.

SEA BRIGHT. Eleva. 7.89 ft.
A cross on the outer edge at the north end of bluestone door sill of entrance, on the west face of the railroad station on the west side of the tracks, near the east end of the bridge over the Shrewsbury River.

SEA BRIGHT. Eleva. 7.09 ft.
A cross on the center and topmost point of the southeast concrete base supporting metal frame flag pole at L. S. S. No. 99, on the west side of the railroad tracks about one mile north of Sea Bright Railroad station.

SEA GIRT. Eleva. 20.36 ft.
A cross on the northeast corner of southeast concrete pier supporting automatic signal frame at the crossing just below the railroad station. The pier is east of the tracks.

SEA GIRT. Eleva. 19.49 ft.
A cross on a small ledge of stone chimney at the north end of Governor's cottage, near the railroad station. The cross is about .7 foot below the water-table of building and .4 foot from the west edge of the chimney.

SEA GIRT. Eleva. 26.98 ft.
A cross on the southwest corner of the southwest concrete pier supporting frame of water tank west of the railroad tracks and about 300

SPRING LAKE BEACH. **Eleva. 28.16 ft.**
A cross on the north end of bluestone door sill on the west face and at the northwest corner of brick school building at 5th and Warren Avenues. The structure is diagonally across the park from the railroad station.

SPRING LAKE BEACH. **Eleva. 18.35 ft.**
Elevation of underground mark 13.98.
A stone monument on the east side of Ocean Avenue about 20 paces south of and at right angles to the south curb line prolonged, of Washington Avenue, and about 30 paces east of the west curb line of Ocean Avenue as it is put down in front of Life Saving Station No. 8 (old number). The bearing from the stone to the nearest corner of the station, which is now on the northwest corner of Washington and Ocean Avenues, is about 20° northwest and the distance about 60 paces. The monument projects a little above the surrounding surface. The bench mark is known as No. 4, as recorded in N. J. Geological Survey Report of 1888.

TENNENT. **Eleva. 76.65 ft.**
A cross on the level of the girder seat and on the outer corner at the northerly end of easterly concrete abutment of P. R. R. bridge, over Wemrock Brook, about ¾ mile northwest of the station. The cross is 15½ feet from the bridge railing.

TENNENT. **Eleva. 90.59 ft.**
A cross on the easterly end of cement door sill of entrance to waiting room on the southwest face of the railroad station.

TENNENT. **Eleva. 89.13 ft.**
A cross on the outer corner at the northeast end of cement door sill of double door entrance, on the westerly face of factory of the Tennent Products Company, on the southeast side of, and back 150 feet from Main Street, 325 yards northeast of the railroad station.

TENNENT. **Eleva. 121.75 ft.**
A cross on the level of the girder seat and on the southwest corner of a large stone on the south end of east abutment of railroad bridge over a highway, about one mile east of the station.

TENNENT. **Eleva. 140.07 ft.**
A cross on the level of the girder seat and on the southwest corner of a large stone at the south end of east abutment of railroad bridge over highway, about 1¾ miles east of the station. The bridge is about 100 feet southerly from the Freehold-Tennent highway.

WATER WITCH. U. S. C. S. -14. **Eleva. 9.39 ft.**
A red metal disc in the concrete base of a signal pole about 0.9 mile west of the railroad station. The signal pole is north of the railroad track and close to the rip rap sea wall.

WEST END. (HOLLYWOOD.) **Eleva. 24.71 ft.**
A cross on the southeast corner of the stone on which the north end of east girder rests at the east end of north abutment of railroad bridge over a roadway near Lake Takanassee, about ¼ mile south of the West End-Hollywood station.

WEST END. (HOLLYWOOD.) **Eleva. 12.26 ft.**
Elevation of underground mark 7.57 feet.
A stone monument on the lot of the Life Saving Station No. 5 (old number), 10 feet measured perpendicularly from the middle of the west end of old station building, which is along the lake and south of the new station. The line of face of north abutment of the new Ocean Avenue bridge over Lake Takanassee passes 6 feet to the south of center

of monument, and the stone is 229.5 feet east of the east curb of Ocean Avenue. The top of the monument is about .5 foot below the surface of the ground. (This is monument No. 3, N. J. G. S., Report of 1888.)

WEST END. (HOLLYWOOD.) Eleva. 26.33 ft.

A cross on the northeast corner of cement pier supporting iron column of roof at the southeast corner of the railroad station building on the west side of the tracks. The cross is about .75 foot above the cement platform.

WEST END. (HOLLYWOOD.) Eleva. 23.93 ft.

A cross on the east end of bluestone door sill of center entrance on Brighton Avenue to the Henry Hotel on the corner of Palmer Street about one block east of the railroad station.

WICKATUNK. Eleva. 116.88 ft.

A cross on the outer edge at the center of east parapet of concrete culvert under the railroad about 300 yards north of the station. The cross is considerably below the track.

WICKATUNK. Eleva. 147.83 ft.

Bottom of water table at the northeast corner of William Smock's residence, west of the track, directly opposite the railroad station.

WICKATUNK. Eleva. 159.52 ft.

A cross on the southeast corner of a red brick on the southeast corner, at the south end of west pier supporting frame of overhead highway bridge over the railroad, just south of the station.

YELLOW BROOK. Eleva. 82.10 ft.

A cross on the southeast corner of fourth stone step from the girder seat at the southerly end of westerly abutment of P. R. R. bridge over stream about ½ mile westerly from the station.

YELLOW BROOK. Eleva. 88.46 ft.

A cross on the northwest corner of concrete base of bell signal on the southerly side of the railroad track at crossing, by the station.

YELLOW BROOK. · Eleva. 88.89 ft.

An iron hub at the center point between the rails and marking the P. C. of a curve to the right, at mile post 10-23, just east of the station. There is a large cross in the top of the iron post.

REPORTS OF THE
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
STATE OF NEW JERSEY

Division of Geology and Waters
HENRY B. KÜMMEL, *State Geologist*
In cooperation with the United States Department of Agriculture—
Bureau of Soils—MILTON WHITNEY, *Chief*

BULLETIN 20

(Geologic Series)

SOIL SURVEY OF THE BELVIDERE AREA, NEW JERSEY

BY

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Department of Conservation and Development of New Jersey.
H. H. BENNETT, Inspector.

Published August, 1920.

FOREWORD

For a number of years the Department of Conservation and Development, in cooperation with the Bureau of Soils of the United States Department of Agriculture, has been engaged in classifying and mapping the soil types of the State. The progress of the work, and the areas included in the published reports, are shown by the diagram on the back cover.

Reports and maps have been published for the following areas: Sussex, Belvidere, Freehold, and Camden. The report on the Millville area will be issued soon. The field work in the Bernardsville and Chatsworth areas has been completed, and reports written.

Both organizations share equally in the expense of the field work. The reports and maps are printed by the Bureau of Soils, the State Department being privileged to purchase a small edition at cost.

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OF THE DEPARTMENT OF CONSERVATION AND DEVELOPMENT OF NEW JERSEY.

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FIGURE.

FIG. 1. Sketch map showing location of the Belvidere area, New Jersey

SOIL SURVEY OF THE BELVIDERE AREA, NEW JERSEY.

By A. L. PATRICK, In Charge, HOWARD C. SMITH, and J. M. SNYDER, of the U. S. Department of Agriculture; C. C. ENGLE, L. L. LEE, and H. A. MILLER, of the Department of Conservation and Development of New Jersey.

DESCRIPTION OF THE AREA.

The Belvidere area, comprising nearly all of Hunterdon County, about three-fourths of Warren County, about one-third of Mercer County, and small parts of Somerset, Morris, and Sussex Counties, is situated in the southwestern part of northern New Jersey. The Delaware River, its western boundary, separates it from the State of Pennsylvania. It has an area of 764 square miles, or 488,960 acres.[1]

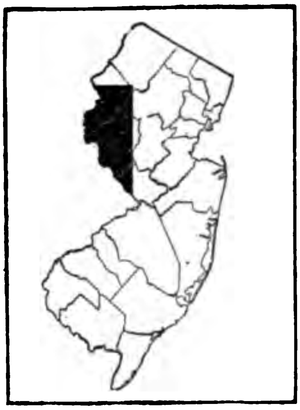

FIG. 1.—Sketch map showing location of the Belvidere area, New Jersey.

Parts of three distinct topographic provinces occur in the Belvidere area, known respectively as the Appalachian Valley, the Appalachian Mountains, and the Piedmont belt. (See Pl. I.)

In the extreme northwest there is a region of flat-topped hills with a somewhat uniform elevation of 600 to 700 feet, whose smooth, and in places steep, slopes descend to narrow valleys cut 100 to 350 feet below the general level. This region is a part of the great Appalachian Valley, the portion in New Jersey being known as Kittatinny Valley. It is crossed at right angles from northwest to southeast by the Delaware River, which flows in a steep-sided, flat-bottomed trench 350 to 400 feet deep and from one-half to three-quarters of a mile wide. A short distance above the town of Belvidere the river turns southwest and flows for 10 miles or more parallel to the southeastern margin of the great valley. In this part of its course the walls of the trench are neither so steep nor so high as in its transverse course, and the river is bordered by somewhat wider bottom lands and terraces.

Southeast of the Appalachian Valley is the Appalachian Mountain province. In New Jersey it is a mountain region 10 to 18 miles in width and is known as the Highlands. It consists of several broad, rounded, or flat-topped ridges rising 400 to 600 feet above the lowlands on either side, and separated from one another by deep valleys, some of which are narrow, while others are as wide as or wider than the intervening ridges The larger topographic features of the Highlands, i. e., certain broad lowland belts and the broader and more massive ridges, show a marked northeast-southwest trend, although many of the minor features are irregular. Near the Delaware the ridges are broken and the intervening lowland belts become wider and coalesce, forming near Phillipsburg a broad, level plain with a general elevation of about 400 feet, while the summits of the neighboring ridges rise to elevations of 650 to 1,070 feet. The chief characteristic of the province in New Jersey is the absence of any sharp mountain peaks. The Highland ridges are broad, flat-topped plateaulike elevations, whose summits over wide areas maintain a closely accordant level which rises northeastward from about 750 or 800 feet near the Delaware to 1,000 or 1,100 feet on Schooleys Mountain and Allamuchy Mountain near Hackettstown in the Belvidere area, and to elevations of 1,400 feet or more farther northeast.

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[1] The base map used is that of the Geological Survey of New Jersey and includes all of Atlas sheet No. 24 and the northwest triangle of sheet No. 27.

The interhighland lowland belts have rolling surfaces 400 to 700 feet below the bordering upland, and the streams which drain them flow in narrow and for the most part shallow trenches, and are bordered by narrow flood plains. The northern part of Hunterdon, the southern part of Warren and Sussex, and the western part of Morris County are the parts of the Belvidere area belonging to the Appalachian Mountain province.

Southeast of the Highlands is the Piedmont belt, a region of somewhat varied topographic expression. As a whole it lies 500 to 600 too steep for cultivation, particularly near the Delaware and other master streams.

In all three provinces the larger features of the topography have been determined by the geologic structure, and are the result primarily of stream erosion on rocks of different hardness. Resistant granite and gneiss underlies the Highland ridges, whereas the northeast-southwest interhighland lowland belts have been eroded along belts of softer and more soluble limestone infolded in the crystalline rocks. The rounded hills of the Appalachian Valley are for the most part slate, with a belt of more soluble limestone along the southeastern margin.

The lower portion of the Piedmont is underlain by relatively soft red shale or sandstone, and intrusive masses of extremely resistant diabase (trap) form the central axis of Sourland Mountain, Cushetunk Mountain, and several isolated hills north and west of Pennington. The broad upland west of Flemington, known as the Hunterdon Plateau, owes its elevation to the resistant quality of massive beds of extremely fine-grained claystone (argillite). The high wooded hills south of Pattenburg are formed by conglomerate beds, the quartzite pebbles of which are so large and so insoluble as not to be readily removed by any agents of erosion. All of these factors are of importance in the study and classification of the soils of the area.

The drainage of the area is into the Atlantic Ocean through the Delaware and Raritan Rivers. Nearly three-fourths of the area is drained by the former stream. Its two most important tributaries are the Pequest and Musconetcong Rivers, which flow southwest across the northern part of the area. A large number of streams only a few miles in length empty into the Delaware River between Trenton and Columbia. The South Branch of the Raritan River flows in a southwest direction to High Bridge, where it breaks through the Highlands and flows in a general southeast direction into Raritan Bay.

The area, as a whole, is well drained, and nearly every farm has a drainage outlet. The Hunterdon Plateau, especially in the vicinity of Croton, is the most poorly drained of any of the large tracts in the area. In the Appalachian Valley and on the Piedmont belt the small streams in many places have cut more than 200 or 300 feet below the general surface. The depth of stream dissection is especially marked in the Piedmont region, along the Delaware River, which has cut its channel in places more than 400 feet deep. Prominent bluffs naturally occur in both the Highland and Piedmont regions. The streams are still actively cutting in most places, and water-power can be developed at numerous sites. Many old mills have been operated at various times in the past.

The northern third of the Belvidere area contains a few small lakes or ponds. Greens Pond or Mountain Lake north of Butzvill is a summer resort of some renown.

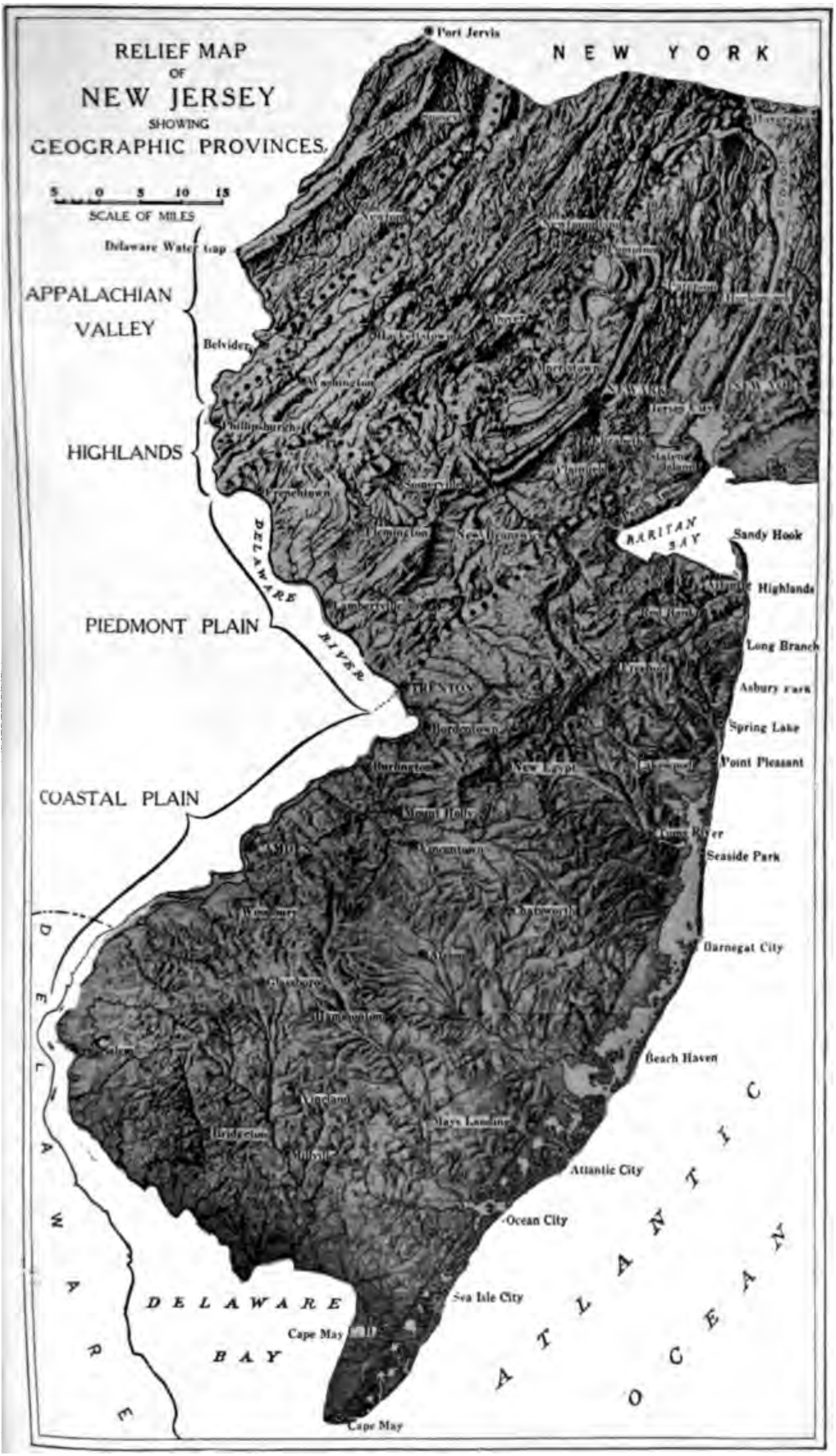
Swedes, English, Quakers, and Holland Dutch all played an important part in the early settlement of this area. The land was purchased from the Indians in 1703, at which time settlements were mad at Lambertville and Ringoes. In 1713 the region now comprisin Hunterdon, Warren, Morris, Mercer, and Sussex Counties was set o from Burlington County. At first the territory separated was call Hunterdon County, and the other counties were organized and sep rated at a later date.

Many of the descendants of the original settlers live in this regi to-day. There are, however, a large number of aliens and foreig born white persons, who are engaged largely in working in th mines at Oxford or in the numerous factories. They are most Poles, Italians, Hungarians, and Germans. Near Great Meado the muck-land farmers are for the most part Poles. The number foreign-born whites has been increasing for many years.

The population of Hunterdon County in 1910 totaled 33,569, whom 7,350 lived in towns of over 2,500 inhabitants. In Warr County the total population was 43,187, of whom 20,185 lived towns.

The average rural population per square mile in Warren Coun is given as 63.5 persons by the 1910 census, as compared with a average of 60 persons in Hunterdon County. The population o both counties is well distributed, except that the mountain regions are somewhat less thickly settled than the valleys. There has been a slow but constant decrease in the population of Hunterdon County since 1870, while the population of Warren County has increased

Report of Bureau of Soils, U. S. Dept. of Agriculture, 1917. **PLATE I.**



GEOGRAPHIC PROVINCES OF NEW JERSEY.

Main lines and branches of the Pennsylvania, the Delaware, Lackawanna & Western, Central Railroad of New Jersey, Lehigh Valley, Philadelphia & Reading, and Lehigh & Hudson River Railroads traverse nearly all parts of the area. A trolley line connects the southern part of the area with Trenton, and another extends from Phillipsburg up the Pohatcong Valley for nearly 15 miles. Bridges across the Delaware River are found every few miles, connecting the farming sections closely with Pennsylvania. In addition, the old Morris Canal and the Pennsylvania Canal connect Phillipsburg, Trenton, and smaller towns with New York and Philadelphia.

There are many improved State and county roads, and more are being built each year. The rural roads are systematically worked, and except during wet seasons are nearly equal to the improved roads. Good telephone service is available to all the farming sections. Adequate school facilities are found all over the area.

CLIMATE.

The climate of the Belvidere area is characterized by cold winters and moderately warm summers. Recorded extremes in temperature range between —19° F. in the winter and 102° F. in the summer, but temperatures even approximating these are very seldom reached. Temperatures of over 100° or below zero never last longer than a few days at a time.

A study of the records of the various Weather Bureau stations shows a considerable variation in temperature and rainfall within the limits of the area. In the northern half the temperature is from 1 to 2 degrees cooler than in the southern half, and the annual precipitation is from 3 to 5 inches greater. Perhaps the most striking difference in climatic conditions is in the length of the growing season as measured by the average date of last and first killing frosts. At Belvidere there is an average growing season of 163 days, from May 3 to October 13, while at Lambertville the season averages 187 days, from April 23 to October 27. As a consequence, quicker maturing varieties of flint corn are grown for grain in the northern portions of the area, while the dent varieties are favored in the southern parts. There is also considerable difference in climatic conditions between the mountain and valley areas. Thus, in the fall of 1917 early frosts in September killed all the corn in the valleys, while that on the ridges lived for a week or ten days longer.

In winter the ground freezes to a considerable depth, and some damage is often done by alternate thaws and freezes. Clover, wheat, and rye sometimes "heave" and winterkill. Buds of fruit trees, especially peaches, often are injured by late spring frosts, particularly on southern slopes in the northern part of the area.

The precipitation is adequate and well distributed through the growing season, being heaviest during the summer months. The annual precipitation has ranged from a maximum of 67.23 inches in 1889 to a minimum of 30.06 inches in 1914.

The following tables give the more important climatic data as recorded at the Weather Bureau stations at Trenton and Belvidere:

Normal monthly, seasonal, and annual temperature and precipitation at Trenton.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year 1914.	Total amount for the wettest year 1889.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	34.4	70	1	3.16	4.64	2.03	3.4
January	30.5	72	−8	3.17	2.72	4.40	7.2
February	30.7	72	−10	3.19	3.00	3.36	10.2
Winter	31.9	72	−10	9.52	10.36	9.79	20.8
March	39.1	86	6	4.04	3.28	5.67	3.8
April	49.8	98	21	3.29	2.57	5.00	.
May	61.1	99	33	3.52	1.98	4.47	.
Spring	50.0	99	6	10.85	7.83	15.14	4.
June	69.5	98	41	3.49	1.74	2.67	.
July	74.5	106	50	4.77	4.75	9.86	.
August	73.0	99	46	5.37	1.63	7.23	.
Summer	72.3	106	41	13.63	8.12	19.76	.
September	66.9	97	35	3.39	.41	10.13	.
October	55.6	89	28	3.41	1.74	4.66	.
November	44.4	78	10	3.43	1.62	7.75	1.1

Normal monthly, seasonal, and annual temperature and precipitation at Belvidere—Continued.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1900).	Total amount for the wettest year (1902).
March	36.8	87	−5	4.04	3.66	4.45
April	49.6	96	15	3.27	2.12	3.57
May	60.7	100	29	3.89	2.31	1.48
Spring	49.0	100	−5	11.20	8.09	9.50
June	69.0	99	39	4.40	3.70	6.65
July	72.7	102	42	5.60	5.37	6.21
August	70.8	99	43	4.96	1.92	4.11
Summer	70.8	102	39	14.96	10.99	16.97
September	65.1	98	31	3.92	2.06	8.83
October	52.5	93	18	3.84	1.54	5.62
November	41.2	75	5	3.49	2.37	1.65
Fall	52.9	98	5	11.25	5.97	16.10
Year	50.3	102	−15	49.62	36.37	61.74

AGRICULTURE.

The pioneer farmers in the Belvidere area had to clear much of the land of a dense growth of hardwoods, and in many places stones had to be removed. The early crops grown were corn, barley, oats, rye, wheat, and some flax. Herds of cattle and hogs were branded and allowed to range in the woods. Nearly every farmer's income was supplemented by the sale of logs, which were rafted down the Delaware River to Philadelphia. Transportation for the first hundred years was by wagon. The principal market for farm products was Philadelphia, followed in importance by New York. Boating up the Delaware was possible only in small boats during high-water periods, usually in the spring, but early in the nineteenth century the Delaware & Raritan, Pennsylvania, and Morris Canals were constructed and aided greatly in developing the country. Until recent years they were important factors in the transportation of bulky commodities. With the building of the railroads about the middle of the nineteenth century the real development of this territory began.

Owing to the good natural growth of grass, cattle raising has always been an important branch of agriculture, though there have been many changes in the form of the industry. The beef cattle raised at first were slowly displaced by dairy cows, and butter and cheese products were made, but with the growth of the large citie the demand for whole milk gradually increased until to-day nearl all the surplus available is shipped directly to the cities. The origina Jersey and Guernsey cattle have been largely displaced by Holsteins The number of sheep and hogs has steadily decreased, and to-da the products from these animals are of minor importance in th agricultural economy.

Peach growing was of primary importance at one time, especiall in Hunterdon County. In 1890 a total of 2,073,322 trees was reported in Hunterdon County, but in 1900 there were only 1,046,391 and the number dropped to 309,476 by 1910.

The present dominant type of agriculture is general farming combined with dairying. Poultry raising is of considerable importance, though there are few exclusively poultry farms. The chief money crop is wheat, but in places rye and buckwheat are important sources of income. Hay, corn, and oats are the principal subsistence crops, of which the surplus only is sold, though this often forms a large part of the farm income. According to the census, the total area in cultivated grasses in Hunterdon and Warren Counties in 1909 was 62,818 acres, producing 71,064 tons of hay.[1] Of the cultivated grasses the most popular are timothy and clover, which are usually grown together. In 1910 there were 36,377 acres of mixed timothy and clover, producing 40,964 tons of hay, or slightly more than 1 ton per acre. The hay is either put in the barns or stacked for feed. Large quantities are fed to work horses and dairy cows, and the surplus is baled and sold in the near-by markets.

In 1909 the two counties produced 1,747,042 bushels of corn, 697,043 bushels of oats, 504,456 bushels of wheat, 158,071 bushels of [redacted] the southern part of the area. Apples are produced in large quantities in places. Irish potatoes and other vegetables, including sweet corn, beans, peas, squashes, pumpkins, and cucumbers, are grown on nearly every farm to supply the home table, and the surplus is sold. Near some of the local markets a few farmers specialize in market gardening.

Dairying is the leading industry on a majority of the farms. In the two counties there are 28,423 milch cows, or an average of over 6 per farm. The milk is sold in neighboring cities, New York and Philadelphia taking all the surplus. The total value of the dairy products in 1909 amounted to $1,415,575.

In 1909 the value of the animals sold or slaughtered in Hunterdon and Warren Counties totaled $1,008,771, while the poultry and eggs produced amounted to $983,927. Of the animals sold or slaughtered, hogs and calves made up nearly 90 per cent of the total value, there being 40,304 hogs and 23,074 calves sold or slaughtered. Most of the hogs are consumed on the farm where raised, only the surplus being sold. There were 31,904 hogs in the two counties in 1909, or an average of over 7 per farm. Hunterdon County stood first among the counties of the State in 1909 in the number of stands of bees and number of poultry.

The topography and type of soil exercise a considerable influence upon the type of agriculture from place to place. In the Highlands rye is grown in larger quantities than wheat, and flint corn is usually grown on the mountains and dent corn in the valleys. The Muck in the northern part of the area is the only soil upon which onions, celery, and lettuce are grown in large quantities, while only on the sandy soils are melons grown extensively.

The farmers report that wheat and corn do better on the Hagerstown and Dover soils than on many of the others, and that the Chester and Montalto soils are naturally better adapted to peach and apple production than many of the other soils. Oats, rye, timothy, and alsike clover are known to do much better on the Croton soils than wheat, corn, and red clover. To some extent these ideas of soil adaptation govern the farm practices.

The farms as a whole are well equipped, and the buildings are well built and usually kept in good repair. They constitute about 40 per cent of the entire farm value. The barns are large, constructed with the idea of storing large quantities of unbaled hay and straw. The cow stables are usually on the ground floor. The large milk companies insist upon cleanliness, and there is always plenty of window space. The farms usually include a number of smaller buildings such as corn cribs, wagon and machinery sheds, milk and root cellars, hog and chicken houses, and of late years garages. In the barnyards many farmers have built feeding sheds, which have at least two sides open. A peculiar form of shed is often used for storing hay or straw, called a "barracks." This consists of four posts and a roof which can be moved up or down as the stack increases or decreases. Silos are becoming more numerous each year.

The equipment of farms in machinery is rather complete, and constitutes approximately 6 to 8 per cent of the whole farm value. Thrashers, shellers, feed grinders, gasoline engines, drills, manure spreaders, 2-row corn planters, 2-row cultivators, corn harvesters, and reapers and binders are found on the majority of the farms. A few tractors are in use. The work horses as a rule are large animals, and are found in sufficient numbers on nearly all farms.

The number of dairy cows ranges from 4 to 20 per farm. They are usually good grade animals, of predominately Holstein blood, and often the herds are headed by pure-bred bulls. Some pure-bred herds are kept in various parts of the area. Next to Holstein, Guernsey and Jersey blood predominates. The hogs are usually Chester Whites, and 6 or 7 are found on the average farm. In 1910, 17.1 per cent of the total value of the average farm in Hunterdon County was represented by domestic animals, and 14.7 per cent in Warren County.

In preparing the land for planting, breaking is usually done with two or three horse turning plows. The land is broken to an average depth of about 6 inches and is subsequently run over with disk or spring-tooth harrows, which is followed by a smoothing harrow; drags and rollers are used to break up the clods where necessary. When land is plowed in the fall for spring planting the disk harrow is usually the first implement used in the spring. The two-horse drill is generally used in seeding wheat, rye, oats, and buckwheat, but a few farmers on rough or steep fields still sow these grains by hand.

early in the spring, and harvested in July or August. Buckwheat is generally grown on fields in which some other crop has failed to make a stand or, owing to a poor season, could not be planted at the proper time. The crop is put in at any time before the middle of July.

Crops are nearly all grown in rotations. The most common rotation consists of corn, oats, and wheat, each one year, and clover and timothy hay, for two or even three years. Rye is substituted for wheat in places where wheat does not thrive.

The census reports show that in 1909, $152,235 was spent for fertilizer in Hunterdon County, an average of $70.18 for each of the farms reporting its use. In Warren County $66,775 was expended at an average cost per farm of $60. The commercial fertilizers used are of many different formulas, but the most common one is a 2–8–10 preparation.[1] Some farmers use phosphoric acid alone. All the stable manure made on the farm is generally applied to sod during the fall or winter before plowing for corn, and a few farmers apply small quantities of commercial fertilizer in the row at the time of planting the corn. Applications ranging from 150 to 400 pounds of commercial fertilizer are applied at the time of planting oats, wheat, and rye. Wheat usually receives 50 to 100 pounds more per acre than oats. The truckers on the Muck lands near Great Meadows often apply as much as 1 ton of commercial fertilizer per acre. Since the war in Europe began the fertilizer systems have greatly changed. Potash is no longer in common use and the formulas generally read 1–10 or 0.85–10.

Until a few years ago liming of the soils was a general practice. Nearly every farmer had a kiln, in which he converted into quicklime limestone fragments gathered from outcrops or quarried. The lime was air slaked and applied to the land. With the scarcity of labor and the high price of fuel liming has been neglected. Many farmers have the erroneous belief that commercial fertilizers take the place of lime. Numerous cement factories within the Belvidere area and across the Delaware River furnish a source of lime for agricultural purposes.

Most of the farmers buy some prepared cow feed, especially during the winter. The census reports that in Hunterdon County an average of $134.32 for each of 1,703 farms was spent in 1909 for this purpose. In Warren County the average expenditure amounted to $151.

The farm labor is performed for the most part without outside help, but many farmers keep a farm hand the year round and nearly all require some extra help during the summer and early fall months.

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[1] Fertilizer formulas are stated in the order nitrogen, phosphoric acid, and potash.

Farm laborers are usually residents of the counties, but in some sections foreigners are hired during the summer. Negroes are employed on a few farms north of Trenton. Owing to the great demand for labor in the many near-by plants and factories, farm help is hard to obtain, and this one drawback has been and is doing more to retard crop production than any other factor. In 1910 the average expenditure for labor on each farm in Hunterdon County was $250.33, as compared with $262 in Warren County. At present laborers hired by the year receive $30 to $40 a month and board. Day laborers receive $2 to $3 a day. In the Great Meadows truck region much of the harvesting is done by women and children, who receive pay according to the work performed.

Farms in the Belvidere area range in size from a few acres up to 200 acres or more. The 1910 census gives the average size of farms in Hunterdon County as 84 acres, of which 70.1 acres consists of improved land. In Warren County the average size was 101.6 acres, of which 78.9 acres are improved.

About 60.8 per cent of the farms in Warren County and about 70.4 per cent in Hunterdon County are operated by the owners. The majority of the rented farms are let on a share basis, the systems of accounting varying considerably, depending on special arrangements. Often the owner furnishes the land, buildings, and permanent fixtures, pays for half the fertilizer and seed, and receives half of the grain. When the owner furnishes the cows, as he often does, he receives a certain proportion of the milk receipts as well. Usually the number of acres to be planted in grain is stipulated in the agreement.

Land values vary greatly, depending on the character of the soil, the topography, the condition of the farm buildings, and the improvements, as well as on the proximity to towns and railroads. The gen-

Age,[1] while in the southern or Piedmont regions the coarse-grained trap or diabase ridges stand high above the general level.

Of the sedimentary rocks the Cambro-Ordovician limestone and shales form the valleys separating the gneiss ridges in the northern part of the area. In the southern part the Triassic shales, sandstones, and conglomerates form probably the greater part of the Piedmont. The extreme southern part of this plain has been thinly covered by unconsolidated gravel and sand of much later origin.

At least two distinct glacial deposits laid down by two ice sheets widely separated in time occur in the northern part of the Belvidere area. The first, known as the Jerseyan, deposited a mantle of drift, but no terminal moraine. It came as far south as the northern border of the Piedmont region and locally encroached upon it. In many places the material accumulated by it has been entirely removed by erosion, and its deposits are of importance only in the wider valleys and on the flat tops of the mountains. Even here erosion has effaced nearly all evidences of glacial topography. So old is this drift sheet that its soluble constituents, notably limestone, have been leached out, leaving only the relatively insoluble flinty sandstone, quartzite, and other siliceous rocks. Rusty-looking quartzite cobbles and gneiss bowlders in all stages of decay are characteristic of this drift sheet.

The later ice invasion was during the Wisconsin glacial epoch. It was characterized by the formation of a strong terminal moraine, with well-marked hummocky topography. It crosses the Belvidere area in a narrow, irregular belt from Belvidere to Hackettstown, and marks the southern limit of the ice sheet during this invasion. The moraine consists of material picked up, transported, partly pulverized, and later deposited by the moving ice sheet along its margin. Where thickest, it attains a depth of 200 or 300 feet. The moraine material reflects in a general way the rocks underlying the region over which the ice had passed. Where it had traversed wide areas floored by limestone, slate, or hard sandstone, as was the case in the Belvidere area, these rocks are conspicuous elements in the moraine, even though the rock on which it rests is gneiss. With the melting of the ice and the gradual withdrawing northward of its margin, a sheet of drift much like that in the terminal moraine was strewn over the uncovered surface. Some of it, chiefly in the valleys, was reworked and redeposited by the streams which flowed from the melting ice. The thinner the drift the more the material it contains has been derived from the rock immediately beneath, and locally it may closely resemble disintegrated residual rock. On the whole the drift deposited by the glacial waters, chiefly i valleys, contains a much higher percentage of foreign material does the drift deposited directly by the ice.

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[1] The treatment of geology in this report is based on the work of the Geological Survey of New Jersey.

Scattered throughout the region of the Wisconsin drift ar beds of former lakes which have been filled or drained. These usually consist of organic material or Muck resulting from tl cumulations of dead vegetation. The largest and most impo is situated at Great Meadows.

The soils of the area are derived either from glacial till, di from the underlying rocks, or from water-laid deposits. The be broadly classed, according to geologic origin, mode of form and topographic position into seven soil provinces, which are s in the table below. These seven groups are further subdivided soil series, on the basis of structure, color, and drainage chara istics. The types, the units of soil classification, are separated w the series on the basis of texture and the content of stone gravel. The relation of the various series to the parent ma and the various soil provinces is shown in the following table

Classification of soils.

Soil province.	Soil material.	Character of bedrock.	Soil seri
Glacial	Glacial till	Limestone	Dover. Washington.
		Shale	Dutchess.
		Gneiss	Gloucester.
Glacial Lake and River Terrace.	Old lakebed material	Organic in part	Clyde.
		Wholly organic	Muck.
	Stratified glacial drift.	Limestone	Fox.
		Shales and sandstones	Chenango.
Appalachian	Residual material.		

Glacial soils.—The glacial soils include all the types north of the late Wisconsin terminal moraine as well as those derived from the till of the Jersey or early drift, which extend 20 to 25 miles farther south. The glacial soils are grouped into four series: Dover, Washington, Dutchess, and Gloucester.

The soils of the Dover series are brown to light brown, with yellowish or slightly reddish yellow subsoils. Often the extreme lower subsoil is slightly lighter in texture than the upper subsoil. Fragments of limestone are scattered through both soil and subsoil. Where the till is thick, as in the moraine, quartzite, gneiss, and flint bowlders and gravel are of common occurrence. Outcrops of limestone occur in many places.

The Washington series is characterized by brown surface soils and reddish-yellow or light-red, moderately friable subsoils. Particles of rock are present through the soil and subsoil, giving a more gritty feel and somewhat more friable structure than is possessed by the subsoil of the Hagerstown series, which the Washington soils closely resemble. Angular fragments and rounded gravel or cobblestones of gneiss, quartzite, flint, and occasionally limestone are present. The parent material consists of old glacial drift remaining here and there south of the terminal moraine, most of it occurring in the valleys over limestone or shale, though some of it is found on the flat mountain tops, over gneiss and over the Triassic shales and sandstones of the Piedmont. Probably limestone was originally present in the material, but if so, it has decayed and disappeared.

The soils of the Dutchess series are light brown to grayish brown, with yellow subsoils. Residual material from the underlying shale is encountered within the 3-foot section in places. The subsoil is friable, although somewhat heavier than the soil. Varying amounts of shale particles are found throughout the 3-foot section. Some of the types contain sandstone and quartzite bowlders and gravel. A rolling topography is characteristic of these soils. The parent glacial material is derived mainly from the Martinsburg (Hudson River) shales and slates.

The Gloucester soils are light brown or grayish brown and overlie yellow subsoils. They are derived from the glaciation of local white and gray granitoid gneiss. Huge bowlders and smaller fragments of the gneiss are nearly always present, except where they have been removed by man. Only on the flatter mountain tops and near the foot of the slopes are there noticeable quantities of foreign rocks, usually quartzite, chert, and limestone. The topography ranges from undulating to rolling and even steep.

Glacial Lake and River Terrace Soils.—The Glacial Lake and River Terrace province, as recognized by the Bureau of Soils, embraces two series of deposits. The first included deposits in the basins of lakes formed by the advance and retreat of ice during t Glacial Period. These were either temporary lakes, which to form during the Glacial Period and ceased to exist when the i had passed from that locality, or permanent lakes caused by t reforming of the land surface during the Glacial Period, whi persisted for a long time after the retreat of the ice and which ceas to exist only through the operations of the natural drainage forc The second series of deposits consists of those left by the strea which flowed from the ice. These streams were much larger wh fed by the melting ice than at present. The Clyde soils and Mu owe their origin to the first group of deposits, while the Chenan and Fox soils were formed from the second group.

The Clyde series is characterized by dark-brown or black surfa soils, and gray, drab, or mottled gray and yellow subsoils. T decay of plant remains under swampy conditions has caused t dark color of the surface soils. The lower subsoil is usually high calcium carbonate or marllike particles. The topography is flat a drainage is poor.

Muck owes its origin to the accumulation of thoroughly deco posed vegetation, with which is mixed a small percentage of mine matter. It has been formed under swampy conditions in old la beds.

The Chenango soils are brown, with brown, yellow, or reddis yellow subsoils. The subsoil at a depth of about 3 feet in nearly cases consists of fine sand. These soils occupy terraces along t Delaware River and its tributaries, and consist of reworked glaci material of limestone, shale, and fine-grained sandstone origin, t gether with some material whose origin can be traced to crystalli ing proportions throughout the 3-foot section. The topography is rolling, and the drainage is good to excessive.

The Chester series has grayish-brown surface soils and yellow subsoils. It has been derived from the underlying coarse-grained gneiss, of pre-Cambrian age. Fragments of the parent rock ranging in size from huge masses to small gravel particles are encountered in the soil. The Chester soils occur on the flat tops and sides of the mountains, and differ from the Gloucester soils in mode of formation only.[1]

Soils of the Limestone Valleys.—The soils of the Limestone Valleys province have been derived from limestone, and represent the residual material left upon the removal in solution of the calcium and magnesium carbonates. The soil is thus composed of the impurities in the original rock. The Hagerstown is the only series representing this province in the Belvidere area.

The soils of the Hagerstown series are brown in color, with brownish-yellow or reddish-yellow subsoils. Fragments and small outcrops of limestone are of common occurrence. The topography is gently rolling, and the drainage is excellent.

Soils of the Piedmont Plateau.—The soils of the Piedmont Plateau owe their origin to the weathering of the underlying Triassic formations, which consist of sandstone, shale, argillite, conglomerate, and diabase. The soils resulting therefrom are classed with five series, the Montalto, Penn, Lansdale, Croton, and Lehigh.

The Montalto soils occur in the northern part of the Piedmont region and are derived from the weathering of the underlying dikes and intrusive sheets of trap rock. The surface soil is reddish brown or brown, and the subsoil reddish yellow. The soils occupy high ridges, and this location, together with the fact that they contain large quantities of fine rock particles, have led to the local name of "mountain grit sand." They are also known as "ironstone land."

The Penn series includes the chocolate-red soils derived from the red shales, conglomerates, and sandstones of Triassic age.

The Lansdale series includes brown or grayish-brown soils with yellow subsoils. It is derived from the underlying dark argillite, gray shales, and sandstones.

The Croton series has grayish-brown to brownish-gray or ashy-gray soils, with a yellowish, mottled yellowish and grayish, or light-gray subsurface layer, overlying a very compact, hardpan-like stratum of clay which is brownish red or mottled pinkish and yellowish in color and often contains limonite-yellow and dark friable concretionary material. The soil is residual mainly from brownish-red and dark-colored argillite of Triassic age. The bed rock often is reached within the 3-foot section or at depths not much over 3 feet. In this area the Croton soils occur on a flat plateau into which few streams reach, and as these have very shallow channels and valleys the drainage is imperfect.

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[1] The Chester soils rightly belong in the Piedmont, while the corresponding soils in the Appalachian Mountains are called Ashe. It was not deemed necessary to separate the two in the Belvidere area.

The Lehigh series is characterized by brownish-gray or chocolate-gray surface soils and mottled gray and yellow subsoils. It owes its origin to the breaking down of the underlying shale and argillite, which differ from the rock that has given rise to the Lansdale, Penn, and Croton soils in having been subjected to great heat and pressure by the intrusion of molten material. These rocks have been more or less metamorphosed and have a grayish color. The Lehigh soils in places receive seepage water from the adjacent higher slopes underlain by trap rock and so are locally poorly drained.

Soils of the Coastal Plain.—Although no part of the Belvidere area lies in the Coastal Plain, certain soils occurring along the southern border of the Piedmont, near Trenton, are associated with clayey sand and gravel deposits which are very widespread farther south, but which occur here only as thin, more or less discontinuous patches. The deposit was much thicker and more extensive at one time than it is at present, as its isolated remnants occur widely scattered in the region adjoining the Belvidere area on the east. Within the area surveyed the remnants vary in thickness from 30 inches or less to several feet, and have given rise to one soil series, the Sassafras.

The Sassafras series includes types with brown or grayish-brown surface soils and yellowish subsoils, typically coarser in texture and less compact in structure in the lower part of the 3-foot section. Quartz gravel is found in many places.

These soils occur along streams which flow through or from glaciated areas, and the component sediments are derived from wash from glacial uplands. The Papakating soils differ from the Genesee in being much more poorly drained and in having a darker color.

The Genesee soils consist of dark-brown or grayish-brown alluvial sediments deposited along streams of the Glacial province, and the sediments are derived from glacial upland soils in which some limestone material is present. The Genesee soils are fairly well drained, considering their position in stream bottoms.

The Codorus series is distinguished by brown or bark-brown surface soils and yellowish-brown or brown subsoils. Grit is present throughout the 3-foot section, as well as some flakes of mica. This series represents material washed from upland soils of crystalline origin.

The Bermudian series includes soils which are brown or reddish brown in the surface section and brownish Indian red in the subsoil, with yellowish mottling in many places. They consist of sediments washed from the Penn and Lansdale soils of the upland.

The Roanoke series includes second-bottom soils washed largely from upland types derived from crystalline rocks. The surface soils are gray or brownish gray, and the subsoils are mottled gray and yellow. The latter are usually very compact.

The Birdsboro series has brown or reddish-brown surface soils and yellow or Indian-red subsoil. The members of this series are second-bottom soils occurring along streams of the Piedmont region. They consist of material washed from upland soils derived from the Triassic rocks.

Rough stony land includes nonagricultural areas correlated without reference to color or origin.

In the following pages of this report the various soils of the Belvidere area are described in detail and their relation to agriculture discussed. The distribution of the soils is shown on the accompanying map, and the following table gives the name and the actual and relative extent of each:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent
Chester gravelly loam	69,888	14.3	Croton silt loam	14,976	4.2
Penn shale loam	43,584	8.9	Poorly drained phase	5,632	
Penn silt loam	40,064	8.2	Lansdale gravelly loam	17,024	3.5
Chester stony loam	34,880	7.1	Penn gravelly loam	15,680	3.2
Washington loam	32,064	6.6	Rough stony land	15,296	3.1
Lansdale silt loam	29,184	6.0	Dutchess shale loam	8,320	2.0
Hagerstown silt loam	21,952	4.5	Steep phase	1,472	
Bermudian silt loam	20,736	4.2	Montalto silt loam	9,280	1.9

Areas of different soils—Continued.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Dover loam	7,552	1.8	Muck	1,600	0.8
Sandy phase	1,344		Intermediate phase	1,792	
Chenango fine sandy loam	8,896	1.8	Shallow phase	576	
Chester loam	8,704	1.8	Papakating silt loam	3,584	0.7
Montalto stony loam	8,128	1.7	Sassafras loam	3,008	0.6
Dover gravelly loam	7,552	1.5	Fox gravelly loam	3,008	0.6
Genesee silt loam	6,464	1.3	Fox sandy loam	2,496	0.5
Berks shale loam	6,336	1.3	Chenango fine sand	2,176	0.5
Gloucester stony loam	6,144	1.3	Birdsboro silt loam	1,792	0.4
Gloucester gravelly loam	5,440	1.1	Dutchess silt loam	1,728	0.4
Clyde stony loam	5,376	1.1	Fox loam	1,152	0.2
Codorus loam	4,864	1.0	Roanoke silt loam	448	0.1
Lehigh shale loam	4,800	1.0			
Clyde silt loam	3,968	0.8	Total	488,960	......

DOVER GRAVELLY LOAM.

The Dover gravelly loam is a brown or light-brown loam, quite silty in places, underlain at 8 to 15 inches by yellowish-brown, friable clay loam to gritty, friable clay. In depressions and on some flats and lower slopes receiving wash from adjacent slopes the soil is more silty, deeper, and often slightly darker. Small angular and rounded fragments and bowlders of sandstone, quartzite, flint, quartz, limestone, and in places of gneiss and shale are plentiful on the surface and throughout the 3-foot section. In places the material is very gritty and contains a relatively large proporton of sand. The soil in general is derived from till containing much limestone, but in some places, as in the vicinity of Hackettstown, the original lime-cleared areas is red cedar, oak, hickory, ash, maple, and some chestnut. Most of the chestnut trees are dead or dying. The type is used for growing corn, oats, rye, wheat, buckwheat, and timothy and clover, in conjunction with dairying, the cattle being pastured on the adjacent low or stony soils. As a whole the type is handled similarly to the Dover loam, and the returns are nearly as large. This soil is harder to cultivate, because of its irregular and gravelly surface, and in places the slopes are so steep that improved machinery can not be used.

The type is well suited to the present system of agriculture. The steeper slopes are well adapted to orcharding, all the common fruits succeeding. On some of the steeper slopes the soil would be especially benefited by the growing of winter cover crops. The former practice of liming every four or five years was a good one and should be revived.

DOVER LOAM.

The Dover loam consists of a brown to light-brown, gritty loam or silt loam, 8 to 15 inches deep, overlying yellowish-brown, gritty clay or gritty clay loam which passes quickly into yellow or reddish-yellow, friable sandy clay. In places the lower subsoil is somewhat more sandy than the upper subsoil. Gravel and occasional bowlders of limestone, gneiss, quartzite, and chert are present in some areas.

The type is derived from glacial till containing varying amounts of limestone. It occurs in the northern third of the area, principally in the vicinity of Allamuchy, Mount Hermon, Shiloh, Townsbury, Petersburg, and Hope. The topography is slightly undulating, as at Townsbury and Vienna; gently rolling, as near Mount Hermon; or sloping, as west of Allamuchy and south of Hope. In all cases the slope is sufficient to give both the surface soil and subsoil good natural drainage.

This is not an extensive type, but it has a high agricultural value. It is nearly all cleared and cultivated, though there are a few patches of second growth cedar and oak. Corn, timothy, and red clover, rye, oats, wheat, and buckwheat are the leading crops. Nearly every farm has a herd of dairy cows, numbering from half a dozen to 30 or more. The average herd consists of about 12 cows and a bull. Very few of the herds are pure bred, but nearly all consist of good grade animals of predominant Holstein blood. Fully 80 per cent of the milk is shipped to New York or local markets, but a few farmers make butter for sale and nearly all make sufficient for home use. Hogs are kept on nearly every farm in sufficient numbers to supply the household with pork and lard, and some farmers each year raise a few for sale. Chester White is the most popular breed. Poultry is raised by all farmers, and is the source of considerable income. Only a few horses are raised on the farms, most of work stock being purchased outside the State.

Corn yields range from 40 to 75 bushels per acre, with an aver of about 50 bushels; oats yield 30 to 45 bushels, wheat 15 to bushels, and clover and timothy hay 1 to 2 tons. Alfalfa does w where it has been properly handled, and gives three or four cutti a year. Vegetables, berries, and apples are grown in sufficient qua tities for home use.

Crops are grown in rotations, of which the most common e braces corn, oats, and wheat or rye for 1 year each, followed timothy and clover for 2 or 3 years. In many cases the hay la is pastured after the hay has been harvested, and some farme keep the land in pasture the third or fourth year. The soil is plow fairly deep, with 2 or 3 horse turning plows, and the seed bed well prepared with harrows, rollers, and drags. Improved fa machinery is in common use.

Corn is planted in May or June and harvested in September. usually escapes frost, though occasionally late-planted corn is da aged by an exceptionally early frost, as was the case in 1917. T dent varieties are planted for silage, while flint corn is genera planted for grain.

Oats are seeded very early in the spring and are harvested duri August, in time to plow and prepare the ground for wheat, which sown about September 10 to 20. Timothy is sown with the whe and red clover is sown broadcast with a wheelbarrow seeder in t spring.

Rye when grown takes the place of wheat in the rotation and seeded and handled in about the same way. Buckwheat is used burn it, and return it to the land. This practice is no longer common and the land is showing the effect of lack of lime.

Some stony areas of Dover loam (Dover stony loam) are shown on the map with stone symbols. This soil consists of a brown, gritty loam which passes at 3 to 8 inches into yellowish-brown or yellow, gritty, friable clay. In wooded areas the brown soil is in places only 2 or 3 inches deep, over a subsurface layer of yellow loam. There is an abundance of limestone, and in places quartzite and gneiss, cobbles, bowlders, and gravel. On the shoulders of most of the slopes in the vicinity of Hope the underlying bedrock is very close to the surface and here and there is exposed. The Dover stony loam occurs in large bodies near Hope and Shiloh, where it is largely residual from the underlying limestone. The areas north of Hackettstown consist entirely of till composed largely of limestone material. The topography varies from gently rolling to sloping, with occasional hillocks of very steep, broken land. Much of the surface has a knobby appearance, due to the outcropping of limestone. Drainage is good. Practically none of this soil is cultivated, owing to its stoniness, but most of it is cleared and used as pasture. The characteristic forest growth is red cedar, with a sparse growth of hickory, maple, ash, and oak. Blackberry bushes grow thickly where the land is abandoned. The Dover stony loam is an excellent soil, and it would probably pay to remove the stones where they are not too numerous and where the soil is comparatively deep.

Dover loam, sandy phase.—The sandy phase of the Dover loam consists of brown or light-brown sandy loam or fine sandy loam, 10 to 24 inches deep, over yellowish-brown sandy loam or sandy clay loam. In many places there is considerable fine gravel or coarse grit, consisting mainly of limestone and gneiss, through the 3-foot section, and some large gravel and bowlders are present in places.

The most important areas of the phase are mapped near Vienna, Pequest Furnace, and Warrington, and in other places in the glaciated area. The topography is gently rolling to rolling. Most of the phase occurs on slopes south of the Pequest River, at elevations ranging between 420 and 500 feet above sea level, and it is well drained.

This phase is of small extent, but it is nearly all under cultivation and one of the most productive soils of the area. The same crops are grown as on the typical Dover loam, Irish potatoes being probably a more important crop. Somewhat larger dairy herds are maintained, owing doubtless to the nearness to larger pasture areas, as much of the phase is adjacent to the Genesee and Papakating soils occurring in the rather wide bottoms of the Pequest River. Crop yields differ little from those on the typical Dover loam, and the soil is handled in a like manner. Farmers do not consider the phase to be as strong as the typical soil, and somewhat heavier applications of fertilizer are necessary on the phase in order to produce equal yields. The selling value of the land ranges from $35 to $90 an acre.

The Dover loam, sandy phase, would be benefited by the addition of lime and the incorporation of organic matter, as by turning under vetch and rye. These or a similar crop could be planted in the corn fields at the last cultivation. If allowed to lie on the land these would prevent erosion during the winter months and in this way prevent loss of fertility through leaching.

WASHINGTON LOAM.

The Washington loam is a brown, mellow loam, 10 to 15 inches deep, overlying reddish-yellow, moderately friable silty clay, which is usually quite gritty, especially in the lower part, and which contains small fragments of partly decomposed rock, giving greater friability than exists in the Hagerstown subsoil. There is always more gritty material or small fragments of rock through the entire 3-foot section than in the Hagerstown. In places the surface soil is distinctly reddish-brown when moist and the subsoil is dull red. Large cobblestones or angular fragments of gneiss, quartzite, and bluish-black flint are nearly everywhere present. The more gravelly areas are shown on the map by gravel symbol. In some places the quartzite is almost sufficient to make the soil a gravelly loam. Near Apgars Corner and Potterstown the type as mapped contains sufficient sand to be a sandy loam, but owing to the very small acreage of this character it is not separated. Some areas of Washington silt loam and some Hagerstown silt loam are included with the type.

The Washington loam occurs in the north-central part of the area, mainly in the valleys, where it is associated with the Hagerstown silt

In general yields and methods of handling and fertilization the type differs little from the Hagerstown silt loam. Because of the numerous stones it is often somewhat more difficult to till. In the past century most of the larger stones have been removed and piled along the fence rows. Land values are slightly lower than in the case of similarly situated areas of the Hagerstown soil, but considerably higher than in the case of similarly located Chester and Penn soils.

The Washington loam is productive and generally well managed, and the farmers seem thrifty and prosperous. Better returns would be obtained if more lime were used. On the mountains and on the higher slopes or hills apple and peach orchards, if properly cared for, would probably be profitable.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Washington loam:

Mechanical analyses of Washington loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*	*Per ct.*
170721, 170737, 170741..	Soil..........	4.0	7.6	3.5	10.7	13.0	49.0	12.1
170722, 170738, 170742..	Subsoil......	6.0	8.6	3.5	10.9	8.1	41.4	18.3

DUTCHESS SHALE LOAM.

The surface soil of the Dutchess shale loam is a light-brown to grayish-brown silt loam, 6 to 10 inches deep. The subsoil is a yellowish-brown silt loam to silty clay loam. The entire 3-foot section contains a very high percentage of shale fragments. The depth to bedrock probably does not average over 2 feet, and the shale outcrops in places on the tops of hillocks and the crests of ridges. The rock fragments in the soil vary from small chips to platy pieces 4 or 5 inches across. The unweathered shale is dark colored, black, or bluish black. Foreign bowlders and gravel of quartzite and gneiss and occasionally of limestone occur, and in some places so abundantly that it is necessary to clear the land before cultivating. Gravel and stone symbols are shown on the map in these places.

Large areas of Dutchess shale loam occur in the northwestern end of the area between Jenny Jump Mountain and the Delaware River. Here the type occupies even more rolling areas than the silt loam, and it is very well drained. Crops in fact often suffer from lack of moisture during dry periods, especially where the bedrock is close to the surface.

The shale loam is the most extensive member of the Dutchess series. It is practically all under cultivation, and is used for the same crops as the silt loam. Wheat is not as extensively grown as rye. On some of the steep slopes more hand work is necessary than on the silt loam, but improved machinery is used on most of the type. Owing to the more droughty nature of much of the Dutchess shale loam, the yields do not equal those obtained on the silt loam. Grass is often killed during July and August in the shallower areas.

The Dutchess shale loam needs organic matter and lime. The addition of organic matter will help to retain moisture, and also add to the plant food supply, and large quantities of stable manure or green vegetation should be plowed under. Because of the sloping topography fields should not be left fallow during the winter. Crops such as vetch and rye combined and crimson clover should be sown early in the fall or late in the summer, to be plowed under early the next spring. Apples and peaches would do well on this soil with proper care.

Dutchess shale loam, steep phase.—The steep phase includes very steep slopes of Dutchess shale loam where the soil is shallow and contains frequent outcrops of shale. It is also more droughty than the typical soil.

Part of this rather inextensive phase has been cleared. The chief tree growth on the uncleared areas consists of chestnut and oak. The same crops are grown as on the typical shale loam, but a larger percentage of the fields are kept in grass. The numerous shale fragments help to prevent excessive erosion. Yields are somewhat lower than on the typical Dutchess shale loam.

DUTCHESS SILT LOAM.

The Dutchess silt loam is a brown or light-brown silt loam, 10 to in the few wooded areas consists largely of oak. The chestnut, which formerly was important, has been killed by blight.

Wheat, corn, oats, rye, buckwheat, timothy and clover hay are the principal crops. Dairying is important on nearly every farm, and an increasing amount of corn each year is put into silos for winter feed. Potato culture is gradually becoming more important. The soil seems highly adapted to this industry. Apples do well but there are no commercial orchards on this soil. Wheat yields average about 20 bushels per acre, ranging from 15 to 25 bushels, rye 15 to 20 bushels, and corn 35 to 40 bushels. Clover without applications of lime and manure does not thrive.

The manure made on the farm is usually applied to grass sod just before plowing for corn. Small grains in the rotation usually receive from 150 to 300 pounds per acre of commercial fertilizer at the time of drilling.

Land values on this soil have increased rapidly during the last 10 years, and now range from $35 to $75 an acre, some of the best farms selling for even higher prices.

The type as a whole needs more lime and organic matter. The production of potatoes on a large scale has proved successful on this type in some parts of Pennsylvania. Baldwin and Greening apples are especially well suited to the soil and would greatly increase the profits of the farm, provided the orchards were given proper care.

GLOUCESTER STONY LOAM.

The Gloucester stony loam is a light-brown, gritty loam, 3 to 6 inches deep, over yellowish-brown, gritty loam which passes at about 8 inches into yellow, very gritty loam or clay loam. The material is more gritty than any of the Dover or Dutchess soils, the grit consisting of particles of quartz and feldspar and small fragments of the underlying gneiss. In the densely wooded areas the yellow subsurface material often underlies the brownish layer at only 1 or 2 inches below the surface, and even in some cleared fields the surface soil is yellowish brown. The subsoil is occasionally reddish yellow. Gravel and bowlders or gneiss are abundant, and there is an occasional bowlder of quartzite, flint, and limestone. Gneiss outcrops occur in many places. Some small bodies of Gloucester gravelly loam are included with the type as mapped, as well as small patches of Rough stony land.

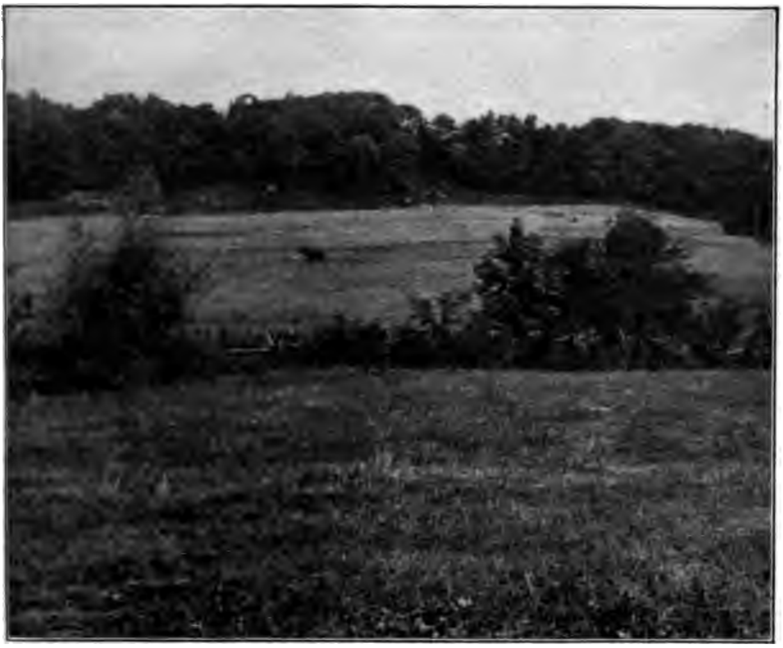
Important areas of Gloucester stony loam occur here and there on the Allamuchy, Mohepinoke, and Jenny Jump Mountains near the villages of Allamuchy, Warrenville, Pequest Furnace, Shiloh, and Bridgeville, where the type occupies mountain slopes, high hills and ridges, and in places gently rolling crests of the mountains. (See Pl. II, fig. 1.) The range in elevation is from 500 to 1,150 feet above sea level. Owing to the surface slope the drainage is adequat though the type is not excessively drained.

The Gloucester stony loam is a wooded type and only a fe patches have been cleared of the forest growth, which consists pri cipally of hemlock, tulip poplar, elm, maple, hickory, basswood, as oak, and birch. The chestnut which formerly was very importa on this type is dead or dying on account of the blight, but youn chestnut shoots are seen around the base of nearly every dead tre Ferns are numerous in the densely wooded areas. Often the lowe slopes approaching the limestone soils are covered with red ceda maple, alder, witch-hazel, and hazelnut.

The principal use of this soil at present is for forestry and pa ture. Where the timber and stones have been removed so as to pe mit cultivation the soil is mapped as Gloucester gravelly loam, an much of the present acreage mapped as stony loam will be so cleare within a few years. Some of the steeper, rougher areas should b left in forest or kept in permanent pasture grasses in order to pr vent washing. Peaches and apples would do well on much of th type.

GLOUCESTER GRAVELLY LOAM.

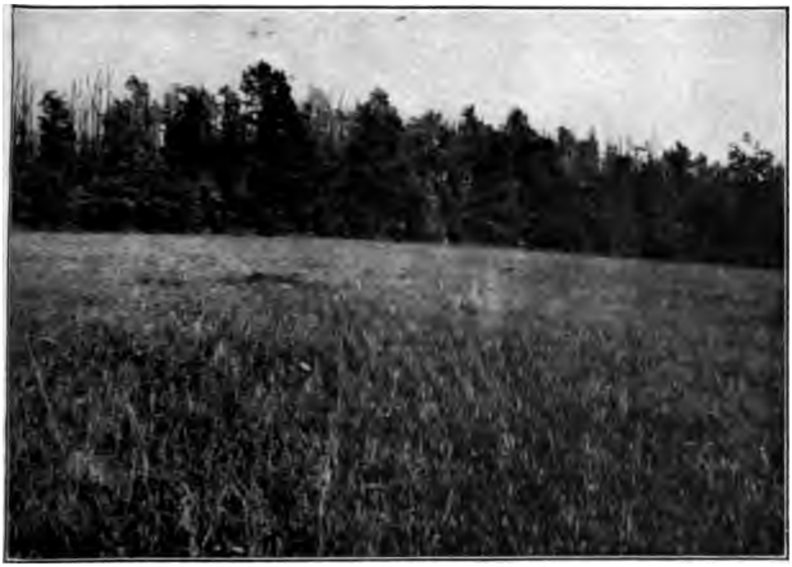
The Gloucester gravelly loam might be considered a "cleare phase" of the Gloucester stony loam, for most of it was undoub edly similar to that soil before the forest growth was cut and cult vation made possible by removing many of the stones and bowlder Huge piles of these stones are seen along the margins of the field and many of the fences are made of the stones picked from th inclosed areas. The surface soil of gritty loam overlying the ye lowish subsoil is 5 to 6 inches deep. In many places it is so fille



S. 9666

FIG. 1.—CLOVER AND TIMOTHY COMING UP THROUGH WHEAT STUBBLE ON THE FOX SANDY LOAM NEAR MOUNTAIN LAKE.

Note the flat topography of the Fox sandy loam. The more sloping surface of the Gloucester soils beyond is characteristic of much of their area. In the middle distance the Gloucester gravelly loam is being plowed for rye. The soil above the plowed field is the Gloucester sandy loam.



S. 9648

FIG. 2.—TIMBER GROWTH ON CHESTER STONY LOAM ON MOUNTAIN NORTHEAST OF HACKETTSTOWN.

The nearly level topography is characteristic of much of the land on the very top of most of the gneiss mountains. Note the numerous dead chestnut trees. The oat stubble in the foreground is on the Chester gravelly loam.

are grown for grain, and yield 35 to 60 bushels per acre. Dent varieties are used for silage. Hay gives only fair yields, ranging from three-fourths to 1¼ tons per acre.

Commercial fertilizer is used in applications varying from 150 to 250 pounds per acre. It is usually applied at the time of seeding the small grains. Manure is spread on the fields to be planted with corn.

This land is held at much lower prices than land of the Dover soils.

The Gloucester gravelly loam is an excellent fruit soil, well adapted to apple and peach culture with proper care. Formerly peaches were produced extensively, but diseases of different kinds killed many of the trees and discouraged the growers. Some of the rougher, cheaper land could well be seeded to permanent pasture grasses, on which large numbers of cattle and sheep could be grazed for several months each year.

CLYDE STONY LOAM.

The Clyde stony loam consists of a black silt loam, 8 to 12 inches deep, overlying gray or mottled grayish, yellowish, and brownish clay, which often contains much limonite-yellow, friable material. Part of the type consists of a dark-brown or rusty-brown silt loam over mottled yellow and gray clay, and some included areas are grayish brown in the soil. Large gneiss stones are scattered through the greater part of the type, but some areas have only the smaller stones and others are stone free.

This soil occurs in drainage-way depressions, along low slopes near drainage ways, and in flats in the areas of gneiss. It occupies only small patches, but the total acreage is rather large. The soil is poorly drained, much of it on account of seepage.

Only a small percentage of this type is thoroughly cleared, but much of it has been partly cleared. Black alder, rushes, calamus, ferns, and skunk cabbage are common in the more poorly drained places, and ash, oak, hickory, black haw, black gum, elm, birch, alder, and maple are plentiful elsewhere. The wooded tracts are used almost wholly for pasture.

Some areas of the Clyde stony loam, after being drained, cleared, and limed, could be made to grow onions, lettuce, cabbage, corn, and hay. It is well suited for use as pasture, as the grasses flourish during periods of drought, when those on the higher upland die.

Some small areas of silt loam soil are included with the Clyde stony loam. They consist of a black or brown silt loam, 6 or 8 inches deep, over ashy-gray to whitish silty clay which passes into mottled yellowish and grayish clay. In places the gray layer is absent and the surface soil lies over the mottled gray and yellow clay Near Broadway there is a small area of nearly black silt loam overlying dark-brown or black, coarse loamy sand to sand. This soil i associated with the Clyde stony loam, differing mainly in containin few or no stones. Some areas are found at the foot of the gneis mountains or near Hackettstown. The land is poorly drained, an little of it is cleared. The vegetation is similar to that on the ston loam, and the chief use of the land is likewise for pasturing dair cattle. Some cleared areas have been drained and give fair cro of corn, hay, oats, and cabbage.

CLYDE SILT LOAM.

The Clyde silt loam is a black or dark-brown silt loam, unde lain at any depth from 8 to 24 inches by mottled yellowish an grayish or grayish-yellow silty clay mottled with rusty brown gray in places. Occasionally the black soil overlies a light-gray sil clay, often mottled with yellow. In places the soil is very nearly Muck, and some small patches of true Muck are included. Alo the southeastern and western borders of the Great Meadows, the are mapped as Clyde silt loam consist of 8 to 10 inches of brown s loam or loam overlying deep black Muck. They really represe the Wallkill silt loam, but owing to their small extent are not sep rated. At the northern end of the Great Meadows between t higher Fox terraces there occur areas of gray silt loam or hea compact sandy loam with mottled gray and yellow clay subsoi The surface soil here is better drained than typical. In some area shown with stone symbols on the map, bowlders of limestone gneiss are plentiful.

FOX GRAVELLY LOAM.

The typical Fox gravelly loam is a brown, mellow loam or silty loam, underlain at 10 or 12 inches by yellowish-brown or yellow friable gritty clay. The lower subsoil is usually lighter in texture and slightly redder in color. Gravel and cobblestones of gneiss, quartzite, and some limestone are plentiful on the surface and through the 3-foot section. The type as mapped at Warrington and near Sarepta differs from the typical soil in containing considerable reworked shale material, some fragments of the rock being present. The soil here might be classed as Hoosic gravelly loam if it were extensive enough to make such a separation practicable. On the terraces 1 miles west of Hampton Junction, and at Van Sickles, and Little York the soil contains much wash, probably from the old drift, in which there is little limestone gravel, but in which there may have been considerable limestone originally. The subsoil here is slightly redder in places than typical.

The largest body of the Fox gravelly loam occurs on the flat terrace of the Musconetcong River at Hackettstown. Here the river flows through the terminal moraine, which contains a large proportion of limestone gravel and bowlders, and undoubtedly the terrace deposits contain much limestone material. Similarly formed terraces are found along the Pequest River at Bridgeville and Belvidere. The type has excellent natural drainage, owing no doubt to the included gravel as well as to the sandy or gravelly nature of the underlying material.

Nearly all the Fox gravelly loam is cleared. It is chiefly devoted to corn, oats, wheat, hay (timothy and clover), rye, and buckwheat. Dairying is an important industry, the cows being pastured on the adjacent bottom lands. Most of the milk is sold to local receiving stations to be shipped to the large city dairies. Alfalfa seems to thrive where it has received proper attention, but it occupies only a very small acreage. Potato growing is increasing in importance, and vegetables, berries of all kinds, and apples are produced in sufficient quantities to supply the farm. A few have a surplus of these crops to sell. Hogs and poultry are raised on every farm to supply the home needs.

This is a productive soil. Wheat ordinarily yields 18 to 20 bushels per acre, rye about 18 bushels, and corn from 40 to 70 bushels, depending on the season and the method of handling. Hay yields 1 to 1½ tons per acre. This soil is well farmed. Crops are usually grown in rotation, and the seed bed is properly prepared by the use of two-horse turning plows, multi-toothed cultivators, drags, and rollers. Crops planted in rows receive several cultivations each season with one or two horse cultivators and hand hoes. Small grain is nearly found on flat or slightly rolling terraces, and is naturally w drained.

Nearly all the Fox loam has been cleared and is used mainly f growing the general farm crops—corn, oats, wheat, and hay. Buc wheat, rye, potatoes, and alfalfa are grown by many of the farme Dairying is an important industry, the cattle grazing on the cheap adjacent soils. Yields are possibly a little larger than those obtain on the Fox gravelly loam. The methods of handling and the ferti zation system are about the same as on the gravelly loam.

The selling value of the loam is practically the same as that o the Fox gravelly loam. Some farmers value the loam a little highe owing to its smaller content of gravel, which makes tillage som what easier.

The Fox loam is an excellent soil, well adapted to the prese system of farming. Lime should be added every few years. Man fields would undoubtedly maintain good stands of alfalfa. Potato could well be worked into the rotation.

CHENANGO FINE SAND.

The Chenango fine sand consists of 10 to 12 inches of brown o light-brown fine sand or slightly loamy fine sand, overlying reddish-yellow or reddish-brown fine sand. Quartz, quartzite, gneiss, and sandstone gravel are found in places. In some places coarse sand, or even fine gravel, is encountered in the lower subsoil, or substratum. There are included with the type, as mapped, some areas which differ from the typical in having a rather loamy surface soil.

On a few islands in the Delaware River and in a few strips along the river there are small low areas which consist of gravel, cobbleroducing melons, cantaloupes, asparagus, and other truck crops. Crops mature 10 days to 2 weeks earlier than on the higher uplands. This soil should be devoted even more extensively to the production f early truck crops for the markets of Trenton, Easton, Philadelhia, Lambertville, Belvidere, and other cities. The soil needs more ganic material and lime. Green-manure crops should be grown, nd plenty of stable manure added.

As mapped, the Chenango fine sand includes some narrow scattered strips of soil along the Delaware River from Delaware to Trenton which really represent the Genesee fine sand. They conist of a light-brown fine sand which shows little change throughout the 3-foot section. The subsoil in some places at about 24 inches grades into a slightly darker loamy sand. In places the surface soil is darker and somewhat more loamy than the subsoil. This soil is well drained, except that in some places it may be inundated by ackwater from the creeks. It is nearly all cleared except in narrow strips along the river, where elm, ash, sycamore, and some sweet gum is found. Much of the type is used for pasture. Corn, wheat, rye, oats, and hay are grown by many farmers. The yields are only fairly good, averaging lower than those obtained on the heavier lands. Near markets watermelons, cantaloupes, pumpkins, squash, turnips, and other truck crops are grown. Truck farmers state that this soil and the Chenango fine sand are the best in the area for these products. This soil needs lime and organic material. Because of its porous, rather leachy nature, it requires rather large quantities of fertilizer. It is essentially an early truck soil.

CHENANGO FINE SANDY LOAM.

The Chenango fine sandy loam consists of a light-brown to brown fine sandy loam to heavy fine sandy loam, underlain at 8 to 12 inches by yellowish-brown fine sandy loam to loamy fine sand. In places the subsoil is reddish yellow. As mapped, some patches consist of loam and others of sand or loamy sand or fine sand. Considerable quartzite, quartz, and sandstone is found in places, and particles of shale occur in the areas north of Belvidere. Where gravel is found in sufficient quantities gravel symbols are shown on the map. In some places, as in the area just south of Belvidere, it is not easy to determine whether the soil is Fox or Chenango, since there are no exposed sections to show the content of limestone material.

The Chenango fine sandy loam occurs on terraces of the Delaware River. It is found in many places from Columbia to Trenton, some of the largest areas occurring near Belvidere, Delaware, Frenchtown, Milford, and Lambertville. The surface is level or nearly level in most places, although northeast of Belvidere it is somewhat billowy. In some places between Frenchtown and Trenton back of the flat typical second bottom there are found remnants of older higher terraces. Here the material seems to be the same as on the lower terraces, though the topography is more sloping. Drainage is good over the entire type.

The Chenango fine sandy loam is nearly all cultivated. The leading crops are corn for grain and silage, oats, wheat, and hay, with rye and buckwheat of secondary importance. Nearer the local markets much of the type is devoted to Irish potatoes, sweet corn, tomatoes, and other truck crops. There is a tomato cannery at Lambertville, and some of the tomatoes used are grown on this type. Alfalfa has done well in the few places where it has been tried and handled properly. Some peaches and apples are grown. This soil in most places is well suited to the use of modern farm machinery.

Dairying is an important industry on nearly all the farms. Holstein blood predominates in most of the herds. There are a few purebred herds and many farmers are gradually improving their stock by the use of good blooded bulls. The average sized herd consists of 12 cows.

Wheat yields are somewhat lighter than on the heavier upland types, ranging from 15 to 20 bushels per acre. Oats yield 25 to 35 bushels, and corn 45 to 50 bushels. Crops are grown in rotations, the most common one being the 5-year rotation of corn, oats, wheat, and hay (combinations of timothy and red clover). The hay is cut two seasons before the sod is plowed under for corn. The dent varieties of corn are grown for both grain and silage purposes, except in the more northern parts of the area, where the flint varieties are grown for grain. The common method of harvesting corn for grain is to cut the stalk near the base and allow the crop to dry in

Land values on this type vary from $30 to $100 or more an acre, depending mainly upon the location with reference to markets. The areas near Trenton often bring very high prices.

The Chenango fine sandy loam under proper management is an excellent soil for general farm crops and for such truck crops as potatoes, late tomatoes, and sweet corn. Alfalfa can be grown successfully, but lime is needed for best results with either alfalfa or clover. The organic supply of the soil could be greatly increased by growing winter crops to be plowed under the following spring.

BERKS SHALE LOAM.

The Berks shale loam consists of brown or chocolate-brown silt loam 6 to 12 inches deep over yellowish-brown or brownish-yellow silty clay, which is slightly reddish in places. There is an abundance of thin to fairly thick or blocky shale fragments on the surface and throughout the soil profile. Typically the shale is thin and the areas of blocky fragments occur in the body of the type southwest of Clinton, which also differs from the typical soil in containing patches of red or reddish shale material. Shale rock in places is frequently reached within less than 3 feet of the surface. Small areas on the tops of many of the knobs and larger areas north of the Clinton and Perryville Road, as well as two small areas south of Stewartsville, differ from the typical soil in having very little fragmentary shale in the surface 20 inches. Quartz, quartzite, and gneiss fragments are present in places on the slopes, especially in the areas between Port Colden and Hackettstown. The unweathered shale is bluish black.

Important areas of the Berks shale loam are found north of Asbury, between Port Murray and Hackettstown, east of Port Colden, and west of Clinton. The type occurs in the valleys associated with the Hagerstown and Washington soils. It has a rolling to hilly topography, the outlines of the hills and ridges being roundish. The range in elevation is from a little less than 400 to slightly more than 650 feet above sea level, the type averaging 150 to 300 feet higher than the rest of the valley soils. Drainage is good to excessive, and crops occasionally suffer in dry seasons, particularly where the soil is shallow.

This type is nearly all cleared and devoted to the general farm crops. Corn, oats, rye, hay, wheat, and buckwheat are grown extensively. Apples and peaches do well, with proper cultural methods. Potatoes and alfalfa are produced by a few farmers. Dairying is an important industry. Corn yields range from 20 to 65 or 70 bushels per acre. Rye yields 15 to 25 bushels, wheat 15 to 25 bushels, and hay 1 to 1¼ tons per acre. Oats do well in places where the soil is deep. Buckwheat is usually grown when some other crop fails. Rotations are usually followed on this soil, and the tillage is generally thorough. The fertilizer practice is about the same that on the other valley types. The corn crop receives most of the stable manure and the smaller grains receive applications of commercial fertilizer.

Land of the Berks shale loam ranges in value from $25 to $ an acre, depending on the location with reference to transportation lines and towns, the surface configuration, and the depth to shale.

This soil is lacking in lime and organic matter. In Lehigh County, Pa., Irish potatoes are grown extensively on this soil, and yields of 200 to 250 bushels per acre are obtained with proper culture and fertilization.

CHESTER STONY LOAM.

The Chester stony loam consists of a brown, gritty loam, 3 or 4 inches deep, grading into yellow, gritty loam, which extends to a depth of 8 to 12 inches, where the subsoil, consisting of yellow, friable, gritty clay loam or clay is encountered. On the surface a layer an inch or so thick consists of dark leaf mold. Large quantities of gneiss fragments of varying sizes occur on the surface and throughout the 3-foot section. The areas which have been sufficiently cleared of stone and timber to permit cultivation are separated and mapped as Chester gravelly loam. In these areas the brown surface material has been mixed through the first 8 inches or more of soil, so that the brownish cast extends much deeper than in the wooded stony loam areas. Small developments of Chester loam and gravelly loam and Rough stony land, which can not well be separated on the map, are included with the type as mapped.

The Chester stony loam, in association with the other Chester soils, forest, as stock can find subsistence on much of the type, and with an increased demand for veal and lambs it would be profitable to inclose areas for pasturage.

CHESTER GRAVELLY LOAM.

The Chester gravelly loam consists of a light-brown or brown, gritty loam, 8 to 12 inches deep, overlying brownish-yellow or yellow, friable, gritty clay loam or clay. The surface layer when dry has a grayish shade. Angular fragments of gneiss are abundant over the surface and through the soil and subsoil, giving the former a decidedly gravelly character. Varying amounts of mica are found. In some places, as near Harmony and south of Broadway, the soil contains large quantities of mica and is redder than typical. Usually it is impossible to bore more than about 15 inches deep with a soil auger on account of the gravel. In places the soil is shallow, the yellowish subsoil coming near enough to the surface to give plowed fields a spotted brownish and yellowish appearance. In the mountains northeast of Bloomsbury there is included an area which differs from the typical in containing more sand.

The Chester gravelly loam is a very extensive soil on the gneiss mountains or uplands south of the glaciated area, where it comprises 85 or 90 per cent of the cleared land. These mountains are situated in the central part of the Belvidere area, where they occur in parallel ridges running in a southwesterly direction across it. The topography varies from steep on the flanks of ridges to gently rolling or nearly level on the crest. The elevation ranges from 700 to over 1,100 feet above sea level, and the soil is well drained, except in a very few places bordering depressions on the ridges where the underdrainage is sometimes imperfect. The gravel helps to make the soil porous but absorptive of moisture. This tends to check erosion.

This type is nearly all cleared and used for the growing of corn, oats, rye, hay, and buckwheat. Some wheat is grown, but most of the farmers state that rye does much better than wheat. Dairying is important on nearly every farm. Most of the milk is sold to local receiving stations. On farms remote from stations the milk is made into butter. A few hogs are raised on each farm to supply pork products for home use, the surplus being marketed. Sheep are raised by a few farmers, and sheep raising promises to become a more important industry.

Apples and peaches do well on this soil. There were large peach orchards on it at one time, but the trees became infected with disease and died. During the last 10 years a few farmers near Lebanon and Fairmount and in a few other places have proved that with good orchard practice good crops of peaches can still be grown.

The flint varieties of corn are usually grown for grain, and the dent varieties for silage. Corn yields from 25 to 60 or 70 bushels per acre; oats 30 to 60 or even 70 bushels; wheat 15 to 25 bushels; rye 15 to 25 bushels; and hay 1 to 1½ tons. Crops are usually grown in rotation and are handled under the general farming methods prevailing throughout the area.

The selling value of land of the Chester gravelly loam is in most cases considerably lower than that of many of the valley soils. This is due largely to the steep hills and the expense of hauling. The price varies from $25 to $75 an acre, depending on the location with reference to good roads, towns, and railroads, and upon the surface configuration and improvements. Many city people pay high prices for some of these farms, preferring them to the valley areas because of the higher altitude and the scenic value.

The Chester gravelly loam is a productive soil, and it responds well to good farming methods. On most farms the soil needs lime. Alfalfa and sweet clover can be grown where proper attention is given to reducing the acidity and adding to the organic content. The soil is well adapted to fruit production, and large commercial orchards if properly handled would do well. Potatoes can be made a profitable crop, and many farmers near good roads could increase their income by growing them commercially.

CHESTER LOAM.

The typical Chester loam consists of a brown to light-brown gritty loam, 8 to 12 inches deep, underlain by a yellow or brownish-yellow, friable, gritty clay subsoil. In places the subsoil has a reddish cast, but this is not typical. Whitish particles, consisting ap-

The Chester loam is nearly all cleared and devoted to corn. oats, wheat, rye, buckwheat, and hay. Dairying is an important industry, much of the milk being sold to dairy companies in the near-by city markets. There are some apple and peach orchards, and where proper care is given the trees good yields of first-class fruit are obtained. Potatoes and alfalfa are grown by some farmers. Yields differ little from those obtained on the gravelly loam member of the series, and this type is handled similarly. Much of it is easier to work, owing to the smaller content of stone and the more even topography. As a consequence the value is usually slightly higher than that of the Chester gravelly loam.

HAGERSTOWN SILT LOAM.

The surface soil of the Hagerstown silt loam is a brown, mellow silt loam, 10 to 15 inches deep, overlying slightly reddish-yellow, moderately friable silty clay which shows no important change to a depth of 3 feet or more. There are some eroded slopes occupied by a clay loam which plows up with a conspicuous reddish cast, especially when moist. Frequently the soil is a brown silt loam to about 10 inches, overlying yellow silt loam or silty clay loam which passes at 20 to 24 inches into reddish-yellow, moderately friable silty clay. Small, whitish or cream-colored particles are common in the subsoil, and occasionally a little dark concretionary material is noticed at a depth of about 30 inches. In some depressions or flats where material has washed in from adjacent slopes the soil is deeper, occasionally ranging to 15 or 20 inches. Fragments of limestone and chert occur here and there over the type. On some knobs or on the shoulders of slopes small limestone outcrops are seen, and the most important of these are shown on the map by outcrop symbols. Some patches of loam are included with the Hagerstown silt loam as mapped. Where the type adjoins areas of Washington loam and Berks shale loam it is often impossible to draw sharp boundaries.

The Hagerstown silt loam occurs in large areas in the Musconetcong Valley south of the glacial region, and in the German, Pohatcong, and Lopatcong Valleys. Important areas also are mapped in the valleys near Phillipsburg, Stewartsville, Bloomsbury, Asbury, Middle Valley, German Valley, Clinton, and Annandale, and at other places in the central part of the area between the gneiss uplands. The type has a gently rolling topography. According to the Geological Survey of New Jersey the elevations range from a little less than 200 feet to slightly more than 500 feet above sea level. Drainage is adequate, but the soil is retentive of moisture.

The Hagerstown silt loam is practically all cleared. It is considered by the farmers to be the strongest and most productive upland soil in the area for general farming. Corn, oats, wheat, an hay (consisting of combinations of red clover and timothy or eithe alone) are the principal crops. Some rye and buckwheat are grown as well as Irish potatoes and alfalfa. Plums, pears, apples, peaches small fruits, and vegetables are grown in sufficient quantities by mos farmers to supply the home needs. Dairying is an important industry on a majority of the farms. The milk is sold to local receiving stations, where it is iced and sent to the city dealers fo distribution. Holstein blood predominates in the dairy herds Many of the farmers are improving their herds by the use of goo blooded bulls. There are a few registered herds. The cattle ar usually pastured on the adjacent bottom soils or on hay fields afte the hay has been cut. Poultry and hogs are raised in sufficien numbers to supply home demands, and the surplus is sold.

Corn yields range from 40 to 90 bushels per acre, averaging abou 55 bushels. An increasing acreage of corn is grown each year fo silage. The dent varieties are grown usually both for grain an silage. Oats yield from 30 to 60 bushels per acre, averaging betwee 40 and 50 bushels. Yields of wheat average about 23 bushels pe acre, with a range from 18 to 35 bushels. Hay yields from 1 to tons, averaging about 1¼ tons per acre.

Crops are grown in rotations, the one most commonly practice consisting of corn, oats, wheat, and hay for two years. Wheat i drilled in, timothy being seeded at the same time. The clover i sown in the spring with a wheelbarrow broadcaster. Good, thoroug tillage methods are practiced. Two and three horse plows, cultivators, harrows, reapers and binders, corn harvesters, etc., are use A few farmers use tractors, which seem to give good results, thoug ared in the Delaware Valley close to many of the areas of this soil. Quicklime could be readily obtained from some of the big dealers the vicinity, or the rock could be burned on the farm as in former years. Many of the kilns are still serviceable. With proper attention to liming, in view of the general productiveness of the soil, alfalfa could be grown in large quantities.

MONTALTO STONY LOAM.

The Montalto stony loam resembles the Montalto gravelly loam except that it contains many larger rock fragments. Where these have been removed the areas are mapped as the gravelly loam. In many places there are outcroppings of the parent bedrock. This rock is used for road making, and places where quarries have been opened up are shown on the map by symbol.

The Montalto stony loam is associated with the other soils of the series. It generally lies on the steeper slopes and is well drained. Most of it is forested, chestnut oak, witch-hazel, basswood, and maple forming the principal growth. About the only agricultural use made of the soil is for pasturing dairy cattle, some sheep, and a few horses.

MONTALTO SILT LOAM.

The Montalto silt loam consists of a light-brown or brown silt loam, which often has a slight reddish cast, especially when moist, and overlies at depths ranging from 12 to 20 inches a yellowish-red or reddish-yellow, gritty clay. In places the soil ranges to a loam, silty clay loam, or clay loam. There are relatively few rock fragments. In some places the subsoil is yellow.

This type is associated with the Montalto gravelly loam. It usually occurs on the gentler lower slopes or the smoother, gently rolling ridge tops. The drainage is good, except in places near the foot of the slopes, where some of the type is imperfectly drained in the lower subsoil.

The type in not extensive, but it is nearly all cleared and used for the general farm crops. Apples and peaches do well where properly handled. It is used in about the same way as the Montalto gravelly loam, the main difference between the two soils being the lower content of stones and the smoother topography occupied by the silt loam. Improved machinery is used on nearly all farms and the wear and tear on implements is not so great as on the gravelly loam. In the region of Round Valley and in other places where the red shales border this type the farm buildings are located on it instead of on the shales, owing to the fact that good water can be obtained more readily in the trap rock formation.

Certain areas shown on the soil map by means of gravel symbols, areas of the silt loam, represent developments of Montalto gravel loam. The type consists of a very gravelly, gritty loam of a rust brown color, grading at 8 to 10 inches into lighter colored, rust brown, gritty gravelly loam, which in turn passes at 15 to 20 inch into reddish-yellow, gritty gravelly clay or clay loam containi whitish particles. The soil is very gravelly from the surface dow the gravel consisting of small angular fragments of the parent tr rock (coarse-grained diabase and locally fine-grained basalt), some places ranging to the size of cobbles. In some areas app ently 50 to 70 per cent of the soil mass consists of gravel and cobbl Occasionally the texture of the soil ranges to a clay loam, whi is more reddish than the gravelly loam.

The Montalto gravelly loam occurs in association with the oth Montalto soils on the trap hills or mountains which rise 200 to 3 feet above the surrounding shale soils. The most important are are those on the slopes of the Cushetunk Mountain surroundin Round Valley, south of Stanton on Round Mountain, and on th Sourland Mountain and associated ridges which begin just south o Lambertville and extend northeast across the area. Smaller patche are found here and there in Hunterdon and Mercer Counties. Th type is found at an elevation ranging from 250 to 450 feet above se level. It usually occupies moderate to steep slopes and rolling ridgy, and hilly country. Drainage is thorough. The gravel con tent helps to keep the soil porous, thus allowing free absorption o moisture, and it also serves as a mulch in places, preventing excess ive evaporation as well as washing. As a result even the quit steep slopes are cultivated.

the Baldwin, Gravenstein, Stayman Winesap, Rome Beauty, York Imperial, and Delicious.

Corn yields 40 to 60 bushels per acre, oats 40 to 60 bushels, wheat 20 to 30 bushels, and hay 1 to 1½ tons per acre. Crops are usually grown in rotations, and good tillage methods are followed. The steeper slopes require more handwork than do some of the smoother areas, where improved farm machinery is used. Stable manure is applied to sod before plowing it under for corn, and the small grains receive 150 to 400 pounds per acre of commercial fertilizer. The type is valued at $40 to $85 or more an acre, depending upon the location and improvements. It is known as "mountain grit land." When properly handled this is an excellent fruit soil, and there is apparently no reason why large commercial orchards would not pay. Lime may be needed in most areas for best results.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Montalto silt loam:

Mechanical analyses of Montalto silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19733	Soil	3.5	9.7	3.8	10.1	9.9	49.6	13.7
19734	Subsoil	6.7	11.7	3.8	9.9	9.9	44.7	14.0

PENN SHALE LOAM.

The Penn shale loam consists of Indian-red silt loam, 8 to 14 inches deep, over brighter Indian-red, brittle clay. There is an abundance of shale fragments from the surface down, and in most places the parent shale occurs within the 3-foot section. This is a common if not universal occurrence on the steeper slopes and especially those approaching streams. Often the lower subsoil is quite friable, owing to the larger quantity of partly decomposed shale material present. The shale fragments range from less than one-eighth to one-half inch or more in thickness. They have practically the same color as the soil. In places where the fragments are not so abundant and the parent rock lies below the 3-foot section the soil is brown and the subsoil reddish brown and friable.

The Penn shale loam is most extensive in the southern part of the area, in the vicinity of Milford and Frenchtown, east and south of Flemington and northeast of Lambertville. It occupies gently rolling ridges, hillsides, and stream slopes, and is often encountered in more level situations where the parent shale is close to the surface. Drainage is usually excessive, especially on the slopes, and the soil may be eroded. Crops often suffer from lack of moisture, especia during dry seasons.

All the type is cleared except the rather steep slopes or places wh the shale is close to the surface. White oak and hickory predomin in the forested areas. Cedar grows on some slopes where the soil thin, while on other slopes beech is an important tree. The type used mainly for growing corn, oats, wheat, and hay. Some rye a buckwheat are grown. Dairying is an important industry.

Yields in very favorable seasons are as high as on the Penn s loam, but the average for a period of years is considerably low The methods of handling and the fertilizer practices are about th same as on the associated soils.

This land is valued at prices ranging from $25 to $75 or more a acre, depending upon the location, the depth to bed shale, and th improvements.

The Penn shale loam needs lime and organic matter. Red clov would do much better if the soil were well limed. The steeper area of thinner soil, should be kept in grass or in forest, and should neve be allowed to go through the winter without a cover crop to preve loss through leaching and excessive surface washing.

PENN GRAVELLY LOAM.

The typical Penn gravelly loam consists of Indian-red or browni Indian red silt loam to loam, underlain at any depth from 10 to 2 inches by Indian-red silty clay, carrying a large quantity of angul fragments and small cobblestones of whitish, grayish, and reddi quartz on the surface and through the soil mass. Usually the soi contains so much gravel that it is impossible to bore to depths greate

[illegible]

[illegible]

[illegible] a good productive soil, naturally well [illegible] to wheat [illegible] [illegible]

[illegible]

PENN SILT LOAM.

Penn silt loam consists of a chocolate colored or brownish red silt loam, [illegible] to 12 inches in depth, overlying Indian red [illegible] clay. Some whitish and reddish [illegible] occurs in places in northern portion of the type, and red shale fragments are present on the surface. The lower subsoil nearly always contains shale particles. The parent red shale is usually encountered at depths ranging from 24 to 36 inches. Occasionally some [illegible] of blue or red argillite occur within the 3-foot section. Penn silt loam is a very extensive soil throughout the south- [illegible] small streams whose valley slopes are smooth. The type is w drained, but only the areas in which the depth to shale is shall ordinarily suffer from drought.

This type is nearly all cleared, the existing wooded areas for t most part consisting of 5 or 10 acre tracts used for woodlots. T principal tree growth consists of red, white, chestnut, and oth oaks, chestnut (which was an important growth before the blig became destructive), hickory, maple, ash, walnut, and sassafr The most important crops grown are corn, oats, wheat, hay (timot and red clover), rye, and buckwheat. Irish potatoes and alfalfa a still minor crops, but their acreage is increasing. Dairying is important industry. Poultry raising is well developed on farms j northwest of Trenton. In this section also there are many farms d voted to the production of nursery stock, especially fruit and orn mental trees, and strawberry, raspberry, and blackberry plants. Ho are raised on most farms to supply pork products for home use, a some farmers have a surplus to sell. Large quantities of peaches a produced on this soil. A few years ago peach production was one the most important industries, and fruit exchanges were maintain at Flemington and other places. The lack of good orcharding pr tice, together with the development of new orchards in southern N Jersey, caused the industry to decline. Apples, plums, pears, a quinces are grown by some farmers and give good returns. This ty is considered by the growers not to equal the Montalto or Chest soils for fruit production.

A considerable proportion of the Penn silt loam has been cult vated for more than 125 or 150 years, and the yields obtained to-d are as a rule as good as, or better than, those obtained on the new [illegible] on sod before plowing it under for [illegible] the rate of 200 to 400 pounds per [illegible] time of drilling the small grains. Wheat [illegible] application of 50 or 100 pounds larger [illegible] usual times 2-8-10 was the common [illegible] 1914 little or no potash is in the fertilizer [illegible] 2-10, 1-10, or even 0.85-10.

Land of the Penn silt loam has [illegible] to $100 or more an acre. From [illegible] most places. Near Trenton the prices [illegible]

The Penn silt loam is well adapted [illegible] crops and to dairying. Yields of [illegible] creased if lime were added in some [illegible] Deeper plowing would probably [illegible] crops could be obtained if more [illegible] selection, and tillage.

Some small areas of Penn loam [illegible] Mercer Counties near Mount Pleasant [illegible] and in a few other places, are included [illegible] because of their small importance and [illegible] cultural value. The Penn loam is a [illegible] derlain at about 10 inches by a [illegible] same color as the soil, resting on a [illegible] the type the material shows little change [illegible] below which there is a higher content of [illegible] Near Mount Pleasant some partly rounded [illegible] in some other places argillite fragments are [illegible] gently rolling, and the type is well [illegible] cleared and is used for the production of [illegible] hay. Some rye, buckwheat, alfalfa, and [illegible] are grown. [illegible] ing is an important industry. [illegible] although peaches do well and in former years [illegible] were set out on this soil. Crop yields average [illegible] the Penn silt loam. The type is handled in the same manner [illegible] easily tilled and mellow.

LANSDALE GRAVELLY LOAM

The Lansdale gravelly loam [illegible] silt loam, underlain at 6 to [illegible] brown silt loam which passes quickly into [illegible] silty clay or silty clay loam. In some places the [illegible] dish cast. There is an abundance of angular [illegible] fragments of grayish and reddish argillite or sandstone, quartzite, and [illegible] the surface and through the soil and subsoil. In areas associated [illegible] the Penn gravelly loam, north of Everittstown, west of [illegible] in a few other places in this same general region (the "Barrens") the stones consist largely of small rounded quartz or quartzite fragments as well as cobblestone of the same material. The stones on the areas mapped southeast of Frenchtown, near Milltown and Rosemont, east of Lambertville, and west of Flemington consist largely of platy fragments of blue or red argillite, while the areas mapped along the slopes of the Raritan contain much platy sandstone.

Included with the type south of Clinton are two small areas of an old, high, river-terrace soil, largely sandy loam, containing large quantities of gneiss, quartzite, flint, and limestone gravel.

The Lansdale gravelly loam occurs in many places in Hunterdon and Mercer Counties. Large areas are mapped south of Croton, near Cherryville, and in many other places. The surface is hilly to sloping. Much of the type is found along stream slopes. Drainage is fair, except in spots where there is seepage from higher slopes.

This is a rather extensive soil. Only a part of it is cleared. The native trees are mainly chestnut oak, red oak, hickory, dogwood, basswood, maple, and chestnut. Near the foot of the slopes in the sections where the gravel is of argillite, beech and elm are numerous. The type is used for general farming and dairying. It gives about the same yields as the Penn gravelly loam except where the gravel consists of argillite; here the yields are somewhat lower. The type is handled under the same methods as the Penn gravelly loam.

Land values on this type range from $20 to $60 an acre, depending upon the location, the kind and amount of stone present (the areas of argillite gravel being of less value than the typical), and the improvements.

The Lansdale gravelly loam needs the addition of lime. This is particularly true of the argillite areas, and here also in places cupies flatter areas than the typical Lansdale silt loam. The incipal areas are situated near Barbartown and Milltown, and uth of Quakertown.

The most important areas of the typical Lansdale silt loam are uated near Quakertown, Cherryville, and Pennington, north of renton, and in other places in Hunterdon and Mercer Counties. The topography on the whole is gently rolling, though in some places e type is found on slopes. Drainage is well established except on e flatter areas, where the subsoil is sometimes imperfectly drained.

This is an important soil agriculturally. Wheat, timothy and clover, corn, oats, rye, and buckwheat are the main crops. The type s nearly all under cultivation, only small tracts of a few acres each eing left in timber, and these are often on the flatter areas. Here chestnut oak, red oak, chestnut, elm, black walnut, maple, hickory, tulip poplar, and dogwood form the principal growth.

Dairying is an important industry, nearly every farmer having from 6 to 18 cows, usually grade Holsteins. The milk is hauled to the nearest milk station, where it is iced and shipped directly to the market. A few farmers who live farther back from the railroads send their milk to the local creameries to be made into butter. The dairy herds are gradually being improved by local breeding, but many cattle are still purchased from New York, Pennsylvania, and Maryland. Hogs and poultry are raised by most farmers in sufficient numbers to supply the home demand for pork and poultry products, and many have a surplus to sell. A few farmers depend almost entirely upon poultry raising for a livelihood. These are generally people who until recently have lived in cities.

Alfalfa does well on this type of soil, and the acreage is being extended. From three to four cuttings are obtained each year. Potatoes are grown by a few farmers north of Trenton and near Pittstown, and very good yields are obtained. The crop matures about the last of August or the first part of September. Dent varieties of corn are grown, the seed usually being selected from the owner's crib. The ordinary yield of corn per acre is 45 or 50 bushels, but there is a range from 40 to 70 bushels.

Wheat yields range from 15 to 25 bushels per acre, averaging about 18 bushels. Rye gives somewhat lower yields than wheat. Hay, which usually consists of a mixture of red clover and timothy, yields about 1¼ tons per acre.

The common practice is to grow crops in a four or five year rotation. Corn, oats, and wheat are each grown for one year, followed by clover and timothy for one or two years. Dairy cows may be pastured in the hay fields the third season. Sometimes rye takes the place of wheat or buckwheat, or it may be sown early to take the place of oats. Usually buckwheat is grown as a catch crop when some other crop fails. Wheat, buckwheat, oats, and rye are usually seede with a drill. Moderately deep plowing is done by most farmer while some plow as much as 8 inches deep. Wheat is drilled fro September 10 to 20, except following seasons when the Hessian fl has caused considerable damage, when it is drilled three or four week later. Timothy is sown with the wheat, and the clover is sown broa cast on the wheat land in the spring. Good seed beds are prepared b the use of two or three horse plows or tractors; disk, spring-toot spike-tooth, and other harrows; and drags and rollers. Cultivate crops such as corn receive many cultivations each season. One an two row multi-toothed cultivators are in common use. Reapers an binders, mowers, hayrakes, manure spreaders, and other improve farm machinery are found on most farms.

The principal commercial fertilizer in former use was a 2-8-1 mixture, but at present, when potash can not be obtained at all, a 1-1 or even a 0.84-10 preparation is commonly used. The stable ma nure made on the farm is usually applied on sod before it is plowe under for corn. From 150 to 250 pounds of commercial fertilize per acre is ordinarily applied at the time of seeding the small grain Burnt lime was used by nearly every farmer until a few years ago but fuel and labor became so high that the burning of the natura limestone was discontinued in the near-by districts, despite the fac that the soil needs liming.

The selling value of this land ranges from $50 to $150 or even more an acre. This wide range is due almost entirely to differences in location. Near Trenton the price is very high.

The Lansdale silt loam as a whole is handled well, but deeper plowing would improve the condition of the soil, and lime in some tion, near Locktown, about 1½ miles southeast of Lambertville, d just north of Birmingham. The topography is usually rather ping and drainage is good or even excessive, except in a few places ere seepage water collects. A considerable percentage of the type s been cleared of the native growth of beech, ash, hickory, and hite, red, and chestnut oak, and is devoted to corn, oats, wheat, rye, uckwheat, and hay. Dairying is an important industry. During wet periods part of the type is used for pasture. Crop yields are bout the same as on the Penn shale loam. Crops do well when the ainfall is well distributed through the growing season, but yields e rather poor when there are droughts, especially in fields where e bedrock is close to the surface. Farmers state that much of this type can be plowed earlier in the season than can the heavier, deeper soils. The value of the land ranges from $20 to $50 or $60 an acre.

In addition to the included areas of Lansdale shale loam, a number of small, unimportant areas of Lansdale loam are included on the soil map with the Lansdale silt loam. They are practically confined to the region between Stockton and Sand Brook. The largest bodies occur on Sandy Ridge and north of Sergeantsville. The soil consists of a light-brown, mellow loam, which passes at 8 to 10 inches into a yellowish-brown loam. In some places the subsoil has a slight reddish cast. In places the soil is quite sandy, approximating a sandy loam, especially in Hunterdon County to the northeast of Sergeantsville and about half way between Stockton and Headquarters. Unweathered bedrock occurs at depths of 3 to 6 feet. Fragments of sandstone, shale, and argillite are found in some places throughout the 3-foot section. The topography is undulating or gently rolling, and drainage is adequate even in wet seasons. About 95 per cent of the Lansdale loam has been cleared. The staple crops grown are corn, oats, wheat, and hay (consisting of combinations of timothy and clover, or either alone). A small acreage is planted to rye, buckwheat, and potatoes. Nearly every farm supports from 6 to 15 dairy cows. Part of this type has been under constant cultivation for 100 to 150 years, and the yields are still good. Hay yields from 1 to 1½ tons, corn 40 to 70 bushels, oats 30 to 50 bushels, and wheat 18 to 25 bushels per acre.

Stony areas of Lansdale loam (representing the Lansdale stony loam) are shown on the map with stone symbols. The Lansdale stony loam is much like the Lansdale silt loam. As most of the type is wooded, the surface half inch usually consists of leaf mold, under which is a dark-brown silt loam underlain at 3 or 4 inches by yellow silt loam or gritty loam which passes into a yellow clay loam to clay. Numerous stone fragments, usually of blue or red argillite, varying in size from that of an egg to pieces several feet in diameter, are found in this type, and in some places outcrops of bedrock occur. Near areas of the Montalto soils the surface material has a grayish cast and the lower subsoil is slightly mottled with yellow and gray. Here some of the rocks look as though they had been subjected to some heat, and many of them seem slightly fused. An important area of Lansdale stony loam occurs 2 miles north of Raven Rock, while another enters the Belvidere area just north of Buttonwood and extends in a narrow belt southwest of Snydertown. The surface is sloping to steep, and drainage is fairly good except in local spots where seepage water from higher slopes accumulates. Very little of this soil is cleared. The forest growth consists largely of red oak, white oak, and chestnut oak, ash, some maple, beech, and elm. Chestnut was once an important tree. The few cleared areas are used almost exclusively for pasture. The steeper slopes occupied by this soil should be kept in forest. Many of the better situated areas are capable of being cleared, and some of them could be made ready for cultivation with little labor.

CROTON SILT LOAM.

The Croton silt loam consists of a grayish-brown to gray silt loam, 5 to 8 inches deep, overlying light-gray silty clay loam which passes abruptly into gray clay and this at any depth from 14 to 24 inches into a very compact, chocolate-brown or reddish-brown silty clay. This hardpanlike layer usually contains considerable brownish or brownish-yellow, more friable material, apparently of a concretionary nature. In many places the upper subsoil is mottled gray and yellow, the yellow mottlings becoming more marked with increase in depth. In places the soil is browner than typical, the upper subsoil is a yellowish silty clay loam passing into yellow silty clay, ton. Other areas are found near Pennington and Lambertville. ainage is poor to imperfect, owing to the flat topography and to hard, impervious subsoil layer, which prevents the proper cir- ation of moisture. Many farms are underdrained.

This is an extensive soil, and most of it is cultivated. The prin- pal native trees are turkey or black oak, ash, birch, maple, hickory, onwood, and post oak. The general farm crops are grown, mainly rn, oats, rye, hay, buckwheat, and some wheat. Dairying is very important industry, nearly every farm having a number of lch cows. The average herd comprises about 12 cows. Holstein lood predominates in the dairy stock. Chickens and hogs are ised in sufficient numbers to supply the home needs, and a few rmers make a specialty of poultry raising.

The yields of oats, rye, and buckwheat are nearly as good on most of the type as on any of the Lansdale or Penn soils. Wheat does not do well. Some farmers report that the crop drowns during the wet periods in the winter. Corn and other deep-rooted crops do not gen- rally give good results except in very favorable seasons, as during very wet years the roots stand in a water-logged soil and during dry periods the "hardpan" layer prevents sufficient moisture from rising. Hay crops do well as a rule. The common hay crop consists of combinations of timothy and alsike clover. Red clover does not do well, except where the drainage is naturally better than typical and where heavy applications of lime have been made.

Crops are grown in rotations, the most common one consisting of corn, oats, rye, and hay. Buckwheat is sometimes sown in July, usually when some other crop has failed to come up or when, because of the late spring, the crop could not be put in at the proper time. Planting is often delayed by the slowness of the soil in drying out. Plowing is done with two or three horse turning plows. Disk, spring-tooth, and spike-tooth harrows, cultivators, and other improved farm implements are in common use.

Corn land generally receives the stable manure, while the small grains are given acreage applications of 150 to 400 pounds of commercial fertilizer, distributed in the row at the time of planting. This soil retains fertilizer much longer than well-drained types, owing to its flat topography and to the underlying "hardpan," which prevents leaching.

The Croton silt loam is known locally as "white land," "swamp land," and "clay land." It has a wide range in selling value, from $20 to $60 or even more an acre, the price depending upon the location with reference to good roads, towns, and improvements. Near Croton and Flemington many farms have been sold at abnormally high figures to city men, many of whom have become discouraged with farm life in a year or two, the farm then going back to th dealer to be resold.

The Croton silt loam is badly in need of lime and artificial drain age. Some of it would be greatly improved by underdrainag though in most cases draining can not be easily accomplished, owin to the hardpan layer. Blasting this layer might improve th drainage.

Croton silt loam, poorly drained phase.—The Croton silt loa poorly drained phase, has a brownish-gray or ashy-gray silt loa surface soil, 6 or 8 inches deep, overlying light-gray or mottled gra and yellow silty clay loam. This passes quickly into mottled, limo ite-yellow, and gray silty clay, which is underlain at 12 to 28 inch by compact silty clay of a limonite-yellow or mottled Indian-re and limonite-yellow color. Rusty-brown and dark-colored concre tionary material is usually present in this hardpanlike lower subso This layer is so hard and impervious that even during the periods excessive rainfall it seems hard and very dry. Slabs of bluish a reddish argillite are present in many places on the surface a through the soil section.

The poorly drained phase is found in association with the typic Croton silt loam, occupying flats or depressions at the head of o adjacent to streams and other places slightly lower than the adja cent typical Croton silt loam and other soils. It is not an extensiv soil, and it occurs only in small tracts.

Part of this phase is cleared. The tree growth differs from that on the typical soil in that there is more birch, ironwood, maple, and willow. Black haw, hazel, and jewelwood grow rapidly. Sedge and rushes often crowd out the other pasture grasses. Pasturing i

LEHIGH SHALE LOAM.

The Lehigh shale loam is a brownish-gray or chocolate-gray silt m passing at 8 to 10 inches into mottled gray and yellow silt loam silty clay loam. In places the subsoil is a bluish silty clay. There an abundance of chocolate-colored and grayish to bluish shale gments on the surface and through the soil and subsoil. In many aces the underlying shale comes within the 3-foot section. Near nton some platy sandstone fragments are scattered over the surce. The color of the soil is grayer than that of the Lansdale soils. The Lehigh shale loam occurs near the Montalto soils. It is proble that the parent rock, the Triassic shale, was metamorphosed by ntact with the dikes and intrusive sheets of molten material which ve rise to the trap rocks of the area. Some of the most important dies of the Lehigh shale loam are encountered in the vicinity of nton, southeast of Union, south of Ringoes, and east of Lambertlle.

The type occupies gentle slopes and is well drained. The motings of the subsoil are not due to imperfect drainage, but have been used partly by the large amounts of shale fragments, which are in ll stages of weathering. During long periods of drought crops ffer on this type from lack of moisture. In places seepage water from the higher Montalto soils gives some trouble.

The Lehigh shale loam is not an extensive type, but nearly all of it is cleared and devoted to the general farm crops. The yields are about the same as on the Penn and Lansdale shale loams, or possibly lower.

On account of their small extent some small areas of Lehigh silt loam are included with the Lehigh shale loam. The surface soil is a gray silt loam, underlain at 6 to 10 inches by mottled gray and yellow silty clay loam to silty clay. In some places the mottling is more vivid than in others. A few fragments of hard, blue argillite or grayish shale are encountered in places. Areas of Lehigh silt loam are associated with the Montalto soils. Some of the most important bodies are situated east of Lambertville in patches on both sides of the trap mountain extending northeast across the area. The topography is gently sloping, and drainage is thorough or even slightly excessive, except where seepage water from the higher lands accumulates. The type is nearly all cleared and used for corn, oats, wheat, rye, buckwheat, and hay. Dairying is an important industry. Yields are only fair, though slightly higher than those obtained on the Lehigh shale loam. The methods of handling the soil and the fertilization practices are similar to those prevailing on the other types of the region.

SASSAFRAS LOAM.

The Sassafras loam consists of 8 to 10 inches of brown, mello loam overlying light-yellow loam which passes quickly throug reddish-yellow or orange-colored loam into reddish-yellow silty cla loam. The lower part of the 3-foot section is lighter in texture tha the upper subsoil, ranging from sandy clay to coarse sand. Varyin amounts of small quartz gravel occur through the 3-foot sectio usually increasing in quantity with depth. In places the surfa soil seems to consist largely of very fine sandy loam. A few bodi are included in which the material that gives rise to this soil is thin that the lower subsoil contains some red material from t underlying red shale.

The material which gives rise to the Sassafras loam in the Belvide area is similar to the soil-forming material of much of the series mapped in southern New Jersey. It is found overlapping the Tri sic shales along the southern border of those formations. In th survey the type is mapped in slightly rolling areas north of Trento near Ewingville and Trenton Junction. It is well drained.

The type is largely cleared and cultivated. The principal tr growth consists of white, red, chestnut, and black oak, dogwood, as and some chestnut. Most of the chestnut trees are dead. The ty is highly prized for the growing of corn, oats, wheat, and ha Some rye and buckwheat are grown, and small areas are devot to alfalfa and potatoes. The yields are equal to those obtained the best parts of the Lansdale silt loam or loam. Much of the type located so close to Trenton that its value for building sites great exceeds its farm value.

y of elm, dogwood, basswood, willow, sycamore, oak, and beech. mucky spots, for example, west of Hope, a marshy growth con- of sweet flag, reeds, and water-loving grasses is found.

Papakating silt loam is used mainly for pasture. The cleared artly reclaimed areas make dependable, permanent pastures, but tter areas can only be pastured during droughts, owing to their condition at other times. Part of the type, as along the northern the Great Meadows, is used for the production of hay, which an average yield of over 1 ton per acre.

s soil could be made one of the most valuable types in the area e production of forage if the drainage were improved and the imed. Cabbage, lettuce, onions, and many other crops should d, as well as the general farm crops.

GENESEE SILT LOAM.

Genesee silt loam, in its typical development, is a brown to rown silt loam, passing at 15 to 20 inches into yellowish-brown lay loam and this into yellow or yellowish-brown, friable, silty The type is exceedingly variable. One boring may show typi- terial, while a few feet away the soil may be much sandier. the streams the sand content is usually larger.

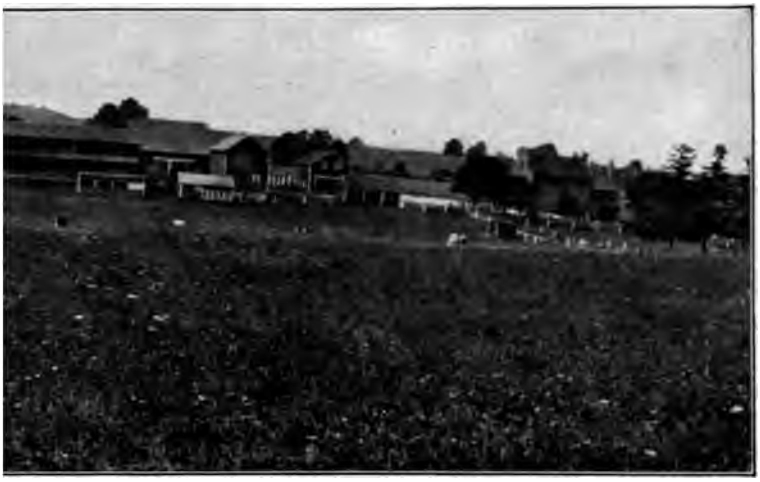
re are included with the type some patches of poorly drained o small to separate. In the Great Meadows some of the bet- ined bottoms have been mapped as Genesee, although the sub- places closely resembles that of the Papakating silt loam. are also some included areas of Genesee sandy loam. In places il contains considerable gravel of gneiss, quartzite, flint, and one, but little mica.

Many of the bottom areas have been cleared of trees and undergrowth. The principal growth in the uncleared areas consists of willow, elm, sycamore, tulip poplar, hickory, maple, and some sweet gum, with an undergrowth of black alder and hazel. The cleared areas are devoted chiefly to pasture grasses. They afford excellent pasturage, even during periods of drought. Dairy cattle are kept by nearly every farmer on the adjacent upland and pastured in the bottoms. (See Pl. III, fig. 2.) Some areas are devoted to the growing of corn, and in favorable seasons very good results are obtained.

CODORUS LOAM.

The Codorus loam typically consists of a brown, gritty loam or silty loam, underlain at 12 or 15 inches by light-brown to yellowish-brown loam or gritty silty loam. In many places the lower subsoil is a sandy clay, sandy loam, or sand, and it varies in color from reddish yellow to yellow or mottled yellowish and rusty brown. Gravel and mica flakes are common in the subsoil, and mica flakes are present throughout the 3-foot section in places. Gneiss gravel and bowlders occur in many places; areas where they are numerous are shown on the map by symbols. Where the drainage is poor the soil and subsoil show more or less mottling with rusty brown or dark drab. There are included some areas of gravelly loam, gravelly sandy loam, and silt loam.

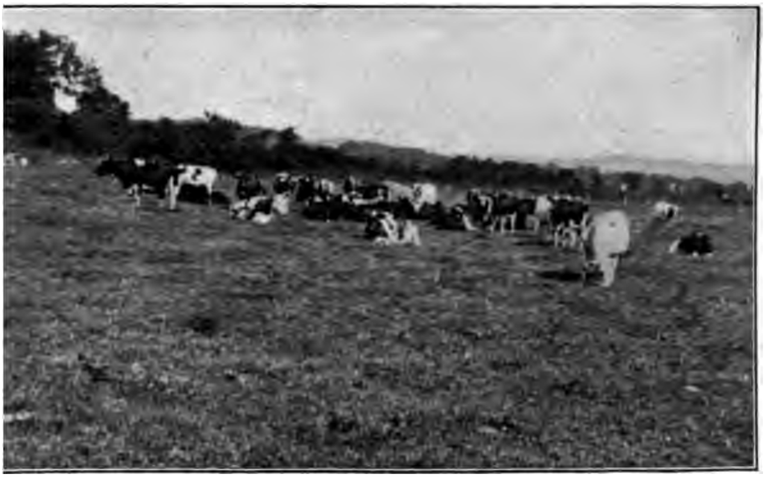
Most of the material giving rise to the Codorus loam is wash from the crystalline-mountain soils (Chester or Montalto), but along some streams it includes wash from the limestone soils, and in fact part of the type really represents the Huntington silt loam. Near the head of some of the drainage ways there is more or less colluvial wash in the shallow depressions.



S. 9647

G. 1.—CHARACTERISTIC GROUP OF FARM BUILDINGS ON THE PENN SILT LOAM, NEAR RINGOES.

The topography is common to much of the type.



S. [illegible]

FIG. 2.—GENESEE SILT LOAM, NEAR GREAT MEADOWS.

Grazing is the principal use made of this soil.

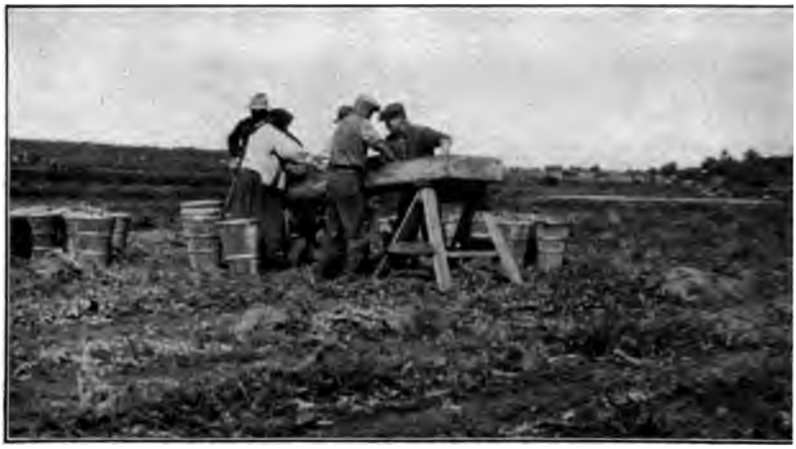


FIG. 1.—HARVESTING AND PACKING ONIONS ON MUCK, NEAR GREAT MEADOW

[illegible]
n places where the drainage is imperfect or poor the subsoil
led red and yellow or gray and yellow or bluish.

Bermudian silt loam is a first-bottom soil consisting largely
h from the Penn and Lansdale soils. It occurs in Hunterdon.
, and Somerset Counties along streams which flow through
nsdale and Penn soils. The largest and widest bottoms occu-
y the type are those along the South Branch of the Raritan
The type as a whole is fairly well drained for a bottom soil.
is subject to overflow during periods of excessive precipitation.
lly where it borders the smaller streams.

rly all the type has been cleared of the native growth of wil-
camore, pin oak, elm, shagbark hickory, ash, and alder. Often
the bottoms have been cleared willow and sycamore are allowed
w along the creek banks. The principal use made of the type
pasturing of dairy cows. It supports a good growth of native
s which, owing to the high level of the water table, do not
much even during periods of drought. Small areas here and
are cultivated, and when the crops are not killed by overflows
ent yields of corn, oats, and wheat are obtained. In most
, however, the risk of loss is considerable, and unless the stream
els are deepened, dikes built, or floods prevented in some other
ultivation of the type is more or less hazardous. Some areas,
er, are inundated so rarely that they can be farmed profitably.

ROANOKE SILT LOAM.

Roanoke silt loam consists of brownish-gray or gray silt loam,
6 inches deep, overlying whitish silt loam which passes at 10
nches into a mottled gray and yellow silty clay containing con-

The Roanoke silt loam has been cleared and is used largely for p turing dairy cattle. Some areas are devoted to the production corn, hay, oats, rye, and buckwheat.

BIRDSBORO SILT LOAM.

The typical Birsboro silt loam is a chocolate-brown or browni Indian red silt loam, 10 or 15 inches deep, overlying Indian-red si clay. In many places, as in the areas near Flemington Junction, t surface soil is a light-brown or yellow-brown silt loam about inches deep, and the subsoil is a yellow silty clay to gritty cl Where the drainage is imperfect the subsoil is slightly mottled wi yellow and red, or yellow and gray. The texture of the soil mapped ranges to a loam or gravelly loam in places. Pockets sand are sometimes encountered, and occasionally the lower substra is sandy in texture.

The Birdsboro silt loam is developed on flat to slightly undulati stream terraces in Hunterdon and Mercer Counties. It represen reworked alluvium derived from Penn and Lansdale material. Th largest areas are mapped along the South Branch of the Rarit River south of Clinton. The type is naturally well drained, thoug patches occur here and there in which the drainage is imperfect. I is not an extensive soil, but nearly all of it is cleared and cultivated Good yields of corn, oats, wheat, and hay are obtained. Corn do especially well in most places. Dairying is an important industry

MUCK.

Muck consists of black, well-decomposed vegetable matter containing some inorganic or mineral material. The organic deposit is 2

cipal plants.
type is important agriculturally, all the larger patches being
ed. Celery, onions, and lettuce are the principal crops, occu-
ully 90 per cent of the developed area. Corn does very well
grown by some farmers who have only a small patch of Muck
ng fields of upland soil. In some cases where this type has
rtly reclaimed it is used for pasturing herds of dairy cows
periods of drought. It is only during such times that it is
to allow stock to pasture on it, because of its miry nature.
ns ordinarily yield from 400 to 800 bushels per acre. Growers
at from 600 to 700 bushels is considered a fair crop, but 900
is often obtained. Varieties of white, yellow, and red onions
own. Celery is the principal crop on most Muck farms.
yields of excellent celery and lettuce are obtained.
is held for the most part in large tracts and leased to
farmers in plots of 8 to 15 acres. The tenants are nearly all
ers, largely Poles. As a rule the whole family helps with
rk. The land is plowed in the fall or early in the spring,
or 2 horse turning plows. The seed is sown in rows usually
8 inches apart. The crops receive many cultivations during
son, small hand cultivators being used. A few growers plant
d in rows 3 feet apart, and till with a one-horse cultivator.
mmon practice is to plant lettuce early in the spring and
as this crop is harvested to follow with celery or onions,
are harvested during September, when lettuce is again planted
arvested the same fall, provided frosts do not come too early.
imes onion seed is planted in September for "sets." Another
n system is to plant early white onions in April and follow

directly to the farms. Each year an increasing percentage of crop is hauled to the markets over improved roads in automo trucks.

The fertilizer formerly used was the common 2-8-10 preparati and 1 ton to the acre was the usual application. Since potash is hard to get the growers use any kind of fertilizer they can obt In 1917 some used 1 ton of a 2-8-3 mixture to the acre, while oth used the same amount of a 1-10 or 2-10 preparation. Some grow believe that the shortage of potash was the direct cause of the practi failure of the lettuce crop of 1917. Stable manure is used by so growers, but they report that weeds are nearly impossible to co trol when this is used, though the effect on the crops is very ben ficial.

Muck lands are rented under both the share and cash rent sy tems. Under the former the owner furnishes everything, includi the seed and fertilizer. He also plows and prepares the seed be and hauls the crop to the freight station. The operator furnish the labor only, and each receives half the crops. The owner dire the work and has charge of selling the crop. Under the cash syste the renter pays $15 to $20 an acre, besides paying rent for the hou and barn. The many smaller details are arranged variously b different persons.

Areas of Muck large enough to sell separately bring from $ to $500 an acre, depending upon the extent of clearing and recla mation, as well as the condition of the ditches, the nearness t good roads, the depth of the organic material, and the building Under the best conditions it is the highest-priced land in the Belv dere area.

Muck, intermediate phase.—The intermediate phase of Muck co ig of onions, celery, and lettuce. Here the yields compare bly with those on the deeper Muck.

th of Vienna in the Great Meadows section a so-called ıs " company has been at work for several years, skimming off ganic mantle right down to the clay or sandy layer, leaving barren area in the place of the once wonderfully fertile mate- Such areas are included with the Muck, shallow phase. Some ›t has been made by the company to reclaim these areas, but ort to this time (1917) has been without success.

ROUGH STONY LAND.

gh stony land includes areas which on account of roughness ·face, due to stones and bowlders, rock outcrops, or steepness pe have little or no agricultural value. Limestone, gneiss, one, and shale stones occur through the soil. The type ents extremely stony or rough areas of several of the regular or shale loam soil types, and does not differ to any extent racter of the soil material.

river bluffs and very steep slopes along the Delaware River important bodies of the Rough stony land. Other important occur here and there along the slopes of the gneiss mountains northern half of the area. Smaller developments are mapped the steep sides of small streams, especially in the shale regions. ıgh stony land is valued almost wholly for the timber. Sheep g might be profitable on some of the less sloping areas.

SUMMARY.

Belvidere area is situated in the southwestern part of north-level. The area falls within two drainage basins, those of the Delaware and Raritan Rivers, the former draining fully three-fourths [illegible] its total extent.

The population is composed largely of descendants of the early settlers and other white persons of native birth. The foreigners as a class are confined to the many manufacturing towns, though locally, as near Great Meadows, foreign-born persons, especially Poles, form the main laboring or renting class.

The area is favorably situated with reference to numerous large centers of population, such as New York City, Philadelphia, and the coal and manufacturing regions of the Lackawanna, Wyoming and Schuylkill Valleys of Pennsylvania. Numerous railroads, canals, and pikes connect all points of the area with these markets.

The climate is characterized by rather cold winters and warm pleasant summers. The growing season in the northern part of the area is nearly a month shorter than in the southern part.

Agriculture in the Belvidere area consists of the growing of such general farm crops as wheat, oats, corn, rye, buckwheat, and hay (timothy and clover), together with dairying. Fruit and poultry products are important locally. Areas of soil especially adapted to the production of celery, lettuce, and onions make these products of great importance in the Great Meadows region.

The soils of the area lie in seven soil provinces, viz, Glacial, Glacial Lake and River Terrace, Limestone Valleys, Appalachian Mountains, Piedmont Plateau, Coastal Plain, and River Flood Plains. Twenty-two series of soils are recognized, including 35 types, in addition to Muck and Rough stony land.

The Washington and Dover soils are considered to be the types of the Glacial province best adapted to grass and corn. The Dutch-of celery, onions, and lettuce. The largest bodies occur near Meadows.

e Berks shale loam and the Chester soils represent the Appa- n Mountain province. The Berks soil occupies rolling areas elevation just slightly above the limestone valleys. It is well ed or even excessively drained, but is well suited to general crops. Irish potatoes seem to do well, though they are not sively grown. The Chester gravelly loam and loam are the two members of the Chester series under cultivation. They ood, well-drained soils, devoted chiefly to the growing of corn, rye, and hay. Peaches were produced in large quantities in r years and a few excellent orchards of peaches and apples to-day. The Chester stony loam is for the most part in forest. upies more sloping areas than the other types and is used only rest and pasture land. Some of it can be cleared of stone and r and converted into tillable land.

e only soil mapped in the Limestone Valleys province is the rstown silt loam, which has a well-established reputation for ctiveness. It is well drained, free from large stones, and in way suited to the growing of general farm crops.

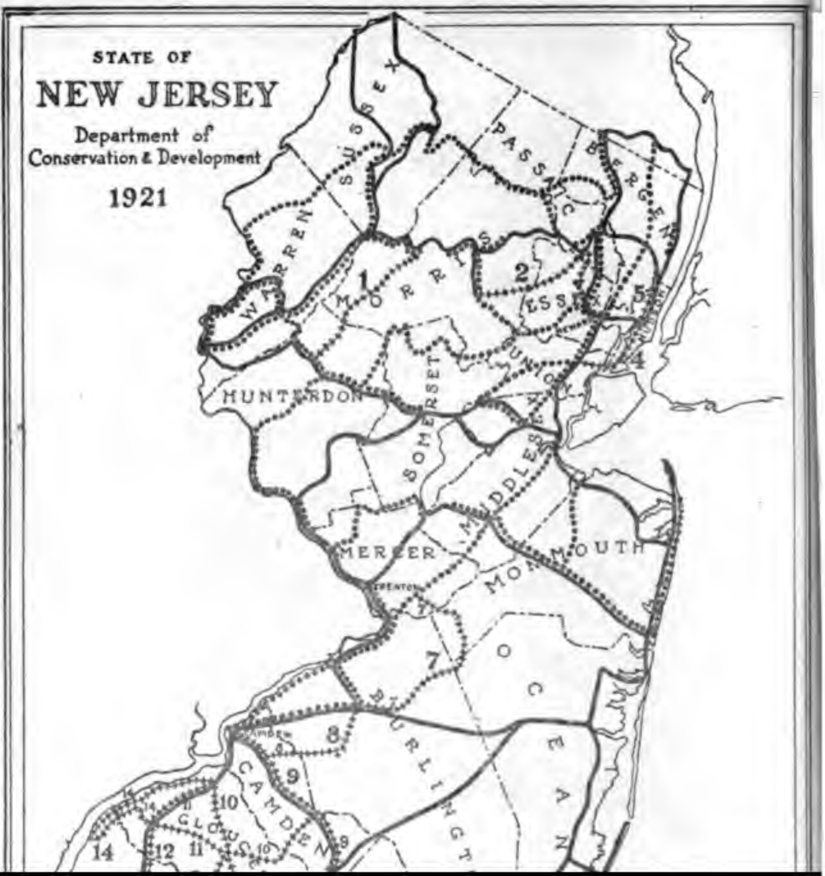
the five series of soils found in the Piedmont Plateau the Penn Lansdale are the most extensive. They are used for the gen- arm crops common to the region. The chief difference between series is in color, the Penn being deeper brown or redder the Lansdale. The silt loam areas of each series are the productive, crops on the shale loam type being subject to ght unless the season be very favorable. The Penn gravelly seems to be better adapted to the production of peaches than ne other soils. The Croton silt loam for the most part is less y esteemed than the adjacent soils. Farmers report that the age is imperfect, and early crops are often drowned out, while ter ones often suffer from drought. Shallow-rooted crops seem best. The poorly drained phase is used almost wholly for re. The Lehigh shale loam is used for the common general crops. It does not give as good returns as the Penn and dale soils. The Montalto stony loam has not been cleared of r. The silt loam of the series is considered to be well adapted uits, especially peaches.

e Sassafras loam is the only type mapped in the Coastal Plain nce. It is a strong, well-drained soil, but owing to its location d near Trenton it is little used for farming.

e River Flood Plains province includes the soils of both the es and second bottoms, and the present flood plains, or first ms.

The first bottom soils of the area are all used for pasturing
cows. They seem to be well suited to this, as they afford
green pasturage when the grass in upland pastures has been
by the hot summer weather. The Papakating silt loam is pro
the swampiest of the bottom soils. The Genesee, Codorus,
Bermudian soils are cultivated in a few of the best-drained
ations. The Birdsboro silt loam occupies the second-bottom
of the Piedmont region. It is a well-drained, productive soil.
Roanoke silt loam is an unimportant soil because of its imp
drainage. It is used chiefly as pasture land.

Rough stony land includes areas where agriculture is impracti
because of the numerous stones and the steep topography.



STATE OF
NEW JERSEY
Department of
Conservation & Development
1921

REPORTS OF THE
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
STATE OF NEW JERSEY

Division of Geology and Waters
HENRY B. KÜMMEL, *State Geologist*

BULLETIN 21
(Geologic Series)

A List of Bench Marks in New Jersey

Revised to 1920

BY

LOREN P. PLUMMER, JR.

Published 1921

TRENTON, N. J.:
PUBLISHED BY THE STATE
1921

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HENRY B. KÜMMEL, Trenton	*State Geologist*

Letter of Transmittal

February 21, 1921.

Hon. Edward I. Edwards, Governor of New Jersey.

SIR—I transmit herewith the manuscript of a report "A List of Bench Marks in New Jersey Revised to 1920," prepared under the direction of Henry B. Kümmel, State Geologist, and recommend its publication.

This report gives the results of the lines of levels which engineers connected with this Department have run at various times, and materially extends the series of established Bench Marks heretofore recorded.

The determination of the exact height above sea level of a large number of points throughout the State, particularly where located in our centers of population, is of great importance to engineers.

Yours very respectfully,
ALFRED GASKILL,
Director.

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Introduction

The work of establishing additional bench marks throughout the State for the use of engineers and others was continued during the field season of 1919. It was in immediate charge of Mr. Loren P. Plummer, Jr., who, under the direction of Mr. C. C. Vermeule, had in previous years run many of the lines described in Bulletins 17 and 19. The work was done with the same degree of accuracy as obtained in the earlier levels and as set forth in detail in these bulletins.

Mr. Plummer with a rodman was in the field during the periods,—April 1–June 28, July 7–14 and November 3–29. The lines leveled over aggregated 347 miles not including many short runs between bench marks. Seventy-four miles of the total were run in the northern counties, while 235 miles were run and 38 miles re-run in South Jersey.

In the northern part of the State the lines leveled over, the length of each line and the closure effected with bench marks that had been established in previous years are as follows:

1. From High Bridge to Wharton via Long Valley and Flanders, along the New Jersey Central Railroad — 25 miles. Checked within — 0.065 feet.
2. Morristown to Montclair via Whippany, Caldwell, Great Notch, along the Morristown and Erie and the Erie Railroad respectively — 23 miles. Checked within — 0.02 feet.
3. Morristown through Great Notch (on line 2) to Little Falls — 19 miles. Checked within — 0.34 feet.
4. Jersey City (near the Pennsylvania Railroad ferries), through Bayonne to Elizabeth — 13 miles. Checked within — 0.19 feet.
5. Jersey City (Court House) along the heights to Guttenburg and return to New Durham, 8 miles. Checked at New Durham within — 0.135 feet.
6. Jersey City (near the Pennsylvania Railroad ferries) to Hoboken and return, 3 miles. Closed within + 0.03 feet.

In the southern part of the State, the lines run and the distance leveled on each line are given below. The routes are shown on the map, Plate 1.

7. Robbinsville to Mount Holly via Allentown, New Egypt, Pemberton and Birmingham, along the highway and railroad — 31 miles.

8. Mount Holly to Camden via Medford and Haddonfield—24 miles.

9. Haddonfield to Winslow via Kirkwood and Atco—22 miles.

10. Atco to Camden via Williamstown, Glassboro, Woodbury and Gloucester and re-run in the reverse direction—total 66 miles.

11. Glassboro to Woodbury via Mullica Hill and Swedesboro — 23 miles.

12. Glassboro to Swedesboro via Elmer, Daretown, Woodstown—26 miles.

13. Woodstown to Salem via Alloway and Quinton—14 miles.

14. Woodbury, Bridgeport, Center Square, Pennsgrove, Center Square, Swedesboro — 32 miles.

15. Elmer to Bridgeton — 13 miles.

16. Glassboro to Vineland—with 5 miles re-run—total 22 miles.

The initial elevation at Robbinsville was an adjusted bench mark on the Perth Amboy–Bordentown line run in 1916. This elevation was carried throughout the above routes. The result of the tests on existing benches in this section as determined from 1885 to 1888 and the distance of each from Robbinsville, is shown in the following table:

Route No.	Distance from Robbinsville Miles	Difference With 1888 B. M.
[redacted]		

the line from Bordentown through Burlington, Deacon, Mount lly and Merchantville was used in conjunction with the original ches as a basis for the final adjustments.

he entire cost of the field work was: Salaries, $1391; traveling enses, $890.26; miscellaneous, $16.87; total, $2298.13, an average $6.62 per mile. As a result of the season's operations, 583 new mary bench marks, and 325 secondary elevations were established, l 18 old bench marks recovered at an average cost of $3.82 per mary bench mark, or $2.48 per mark for both the primary and ondary elevations.

In accordance with custom the primary benches are indicated by sses cut on permanent structures. The secondary points are not tinguished by a mark, but are easily identifiable points, such as il joints, switch frogs, etc. Since these points are subject to ght changes in elevation, their heights are given only to the arest tenth of a foot, and no distinguishing marks have been aced on them. Their elevations have, however, been as carefully termined, checked, and adjusted as those of the primary marks. d they are listed in the belief that where a high degree of accuracy not needed, they may serve equally well, and save running levels om a more distant primary mark. The fact, however, that the evation of most of them is subject to change must not be overoked.

The lists published in the following pages include all the bench arks determined during 1919, as well as some established in preous years, together with many previously published in Bulletins 17 d 19. For some counties as noted in the text these lists supersede l previous lists. For other counties Bulletins 17 and 19 should

A List of Bench Marks—Revised to 1920

Datum plane is mean tide level at Sandy Hook

BERGEN COUNTY.[1]

MIDLAND PARK. Eleva., 191.92 ft.

A cross 5.2 feet west of the west rail and about 1.5 feet lower, on the westerly end of northerly abutment of N. Y. S. & Western railroad bridge over a railroad about 200 yards southerly from the Susquehanna station. The mark is on the horizontal portion of the wing wall nearest the track and is near the vertical break in the wing.

RIDGEWOOD. Eleva., 138.97 ft.

A cross on the water table, 4.5 feet above the sidewalk at the northeast corner of the First National Bank located on the southwest corner of Ridgewood Avenue and Prospect Street.

RIDGEWOOD. Eleva., 135.92 ft.

A cross on the northerly end of blue stone door sill of the up-stairs entrance on Broad Street to the Wilsey building on the northeast corner of west Ridgewood Avenue and Broad Street.

SECONDARY BENCH MARKS.[2]

CAMP GAW. 381.8 ft.

North rail at the station.

CRYSTAL LAKE. 344.4 ft.

Rail at station.

OAKLAND. 273.6 ft.

Rail at station.

WORTENDYKE. 271.2 ft.

Rail at station.

WYCOFF. 345.5 ft.

Rail at station.

BURLINGTON COUNTY.

BEVERLY. Eleva., 35.71 ft.

A cross on the outer corner at the north end of door sill of entrance, on the west face of Beverly Presbyterian Church on Warren Street near Farnum.

BEVERLY. Eleva., 32.65 ft.

A cross on the outer edge at the northerly end of blue stone door sill of Cooper Street entrance to Mechanics National Bank. The cross is immediately below the hinge of the left door.

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[1] See Bulletin 17, 1916, for list of other primary bench marks in Bergen County.

[2] "Rail at station" means rail joint nearest center of station. "Rail at crossing" means rail joint; if there is no rail joint, the elevation is taken on the rail in the center of the roadway.

BEVERLY. **Eleva., 36.22 ft.**
A cross on the south end of door sill of the most southerly entranc on the east face of the public school, a red brick building on Laure Street near Oak.

BIRMINGHAM. **Eleva., 30.88 ft.**
A cross on the northeast corner of the bridge seat at the north end o west abutment of railroad bridge over Rancocas Creek about 0.8 mile east of the station.

BIRMINGHAM. **Eleva., 35.18 ft.**
A cross on the northwest corner of stone on which rests the northerly support of water tower between the Camp Dix and Whitings branc of the Pennsylvania Railroad about one-half mile east of the station.

BIRMINGHAM. **Eleva., 31.33 ft.**
On the most southerly of two bolts on top of the northwest wingwal of bridge over race 100 yards north of Birmingham railroad station.

BIRMINGHAM. **Eleva., 31.09 ft.**
A cross on the northeast corner of a large stone on the north end o southeast wingwall of bridge over race 100 yards north of the railroa station.

BORDENTOWN. **Eleva., 65.78 ft.**
A cross at the foot of the stairway and at the galvanized iron newe post, on the concrete base of water tower, about one mile northeast o the Pennsylvania Railroad station, along the Camden and Amboy branc

BORDENTOWN. **Eleva., 46.77 ft.**
A cross on the north end of the most northerly basement window si of window on the west face of a red brick structure in the yard of th Bordentown Military Academy. The building is the most westerly on on the grounds.

BORDENTOWN. **Eleva., 24.17 ft.**
A triangle cut on coping stone at the east end of the south abutme of railroad bridge over roadway, just north of Bordentown station.

BORDENTOWN. **Eleva., 17.00 ft.**
A cross on the outer corner at the north end of northeast concre abutment of P. R. R. bridge over stream near, and southwest of th station. The cross is on the girder seat and is 15 ft. from the girder..

BORDENTOWN. **Eleva., 57.52 ft.**

NGTON. **Eleva., 16.67 ft.**
he white sandstone water table, and 4.3 feet east of east edge of Street entrance to the Post Office. The point is on the outer edge rectly below west edge of window.

INGTON. **Eleva., 16.90 ft.**
ross on the outer corner at the north end of door sill of most rly (rear) entrance on the east face of Episcopal Church on Broad

STOWN. **Eleva., 79.17 ft.**
the southeast corner of concrete wall of scale pit in front of the nlii.

STOWN. **Eleva., 80.30 ft.**
ross 2.94 feet below the parapet and immediately below the north ı the west cement walk of highway bridge over stream at the mill.

STOWN. **Eleva., 78.60 ft.**
:oss on the center of the north concrete parapet of highway culvert ' New Egypt road 0.2 miles northeast of the mill.

STOWN. **Eleva., 100.33 ft.**
the southwest or outer corner of cement porch floor of dwelling on ›rth side of the railroad opposite the station.

WELL STATION. **Eleva., 80.73 ft.**
per bolt in a monument at the northwest corner of the railroad ı.

WELL STATION. **Eleva., 74.82 ft.**
:oss in the center of cement cap of north stone parapet of highway t just south of the railroad about 0.3 miles west of the station.

ON. **Eleva., 61.64 ft.**
ross on the center of cement cap of east parapet of red brick arch ay bridge, over a small stream about one mile southeast of the P. station, and on the easterly side of the track.

ON. **Eleva., 80.45 ft.**
iangle on the water-table at southwest corner of brick school house, st side of turnpike, three-eighths of a mile southeast of Deacon ı.

ON. **Eleva., 57.77 ft.**
ɔpper bolt in marble slab on the northerly end of easterly parapet R. R. culvert, about one mile southeast of Deacon station.

ON. **Eleva., 76.67 ft.**
ross on the center of concrete cap of west parapet of red brick ıighway culvert about 300 yards southerly from the P. R. R. station ıst of the track.

NCO. **Eleva., 15.27 ft.**
ross on the south end of the southernmost basement window sill dow on the east face of brick school house at the corner of Hickory 'alnut Streets.

NCO. **Eleva., 8.57 ft.**
:oss on the southeast corner of a large stone on the east end of stone pier of P. R. R. draw-bridge over Rancocas Creek. The s 6.5 ft. from the rail, and is on the seat supporting the draw.

WATER PARK. **Eleva., 26.99 ft.**
·oss on the northwest corner of a large stone and on the level of :der seat at the north end of west abutment of P. R. R. bridge over ıy at the station. The cross is 8 ft. from the rail, and immediately face of a stone retaining wall.

EDGEWATER PARK. **Eleva., 28.81 ft.**

A cross on the outer edge at the east end of bottom concrete step of three steps at the southwest corner of the P. R. R. station. Measured northerly, the cross is 5½ feet from the corner of the building.

ELMWOOD ROAD. **Eleva., 63.16 ft.**

Copper bolt in a stone monument at the northwest corner of Elmwood railroad station.

ELMWOOD ROAD. **Eleva., 57.18 ft.**

A cross 1.3 feet below the rail on the topmost point of the north end of a 72-inch cast iron pipe culvert under the railroad about one-half mile west of the station.

FIELDSBOROUGH. **Eleva., 10.56 ft.**

Top of metal cap on which are marked the letters: U. S. E. D., &c. on the westerly side of and near the P. R. R. track, about 200 yards below mile post 26-35, and south of the station.

FIELDSBOROUGH. **Eleva., 6.05 ft.**

A cross on the outer corner of a large stone at the northwest end of easterly abutment of P. R. R. bridge, about one mile below the station. The cross is on the level of the girder seat, and is twelve and one-half feet from the girder.

FLORENCE. **Eleva., 51.82 ft.**

A cross on the northwest corner of concrete base of a hand signal post, a few feet above the P. R. R. station.

FLORENCE. **Eleva., 51.67 ft.**

A cross on the southeast corner of concrete base of a signal at the crossing and on the westerly side of the P. R. R. tracks, about 200 feet below the station.

HAINESPORT. **Eleva., 9.89 ft.**

A cross on the northwest corner of stone on which rests the east end of the north truss of highway bridge over the "South Branch of Rancocas" at J. D. Johnson Company's factory.

HAINESPORT. **Eleva., 12.11 ft.**

A cross on a cap stone of the northeast wing wall of east abutment of highway bridge over the "South Branch of Rancocas." The cross is immediately at the southwest corner of a brick building of the J. D. Johnson works.

RA. **Eleva., 11.53 ft.**
ss on the southwest corner at the south end of east stone abut- P. R. R. bridge, over stream about one-half mile west of station. ss is on the girder seat and 8 feet from the girder.

TOWN. **Eleva., 89.41 ft.**
ss on the northeast corner of concrete base of the easterly railroad just north of the tower about one-quarter mile northerly from the
.

STOWN. **Eleva., 85.70 ft.**
oss on the northwest corner of concrete base of railroad signal on sterly side of the track opposite the station.

ERTON. **Eleva., 37.08 ft.**
er edge at the north end of small marble date stone (1917) set in st face at the southeast corner of brick school one-fifth of a mile f the railroad and about 0.2 miles north of the station.

ERTON. **Eleva., 35.48 ft.**
oss on the outer edge at the north end of cement sill of the most rly basement window on the east face of brick school one-fifth of a est of the railroad and about 0.2 miles north of the station.

ERTON. **Eleva., 37.17 ft.**
oss cut in the most northerly bolt of several bolts holding steel ipe to stone foundation east of the track about 0.2 miles north of ilroad station.

ERTON. **Eleva., 12.47 ft.**
oss 1.8 feet from the girder on the northwest corner of bridge seat west end of south abutment of railroad bridge over South Branch cocas Creek near the station.

E SHADE. **Eleva., 21.51 ft.**
oss on the southeast corner of the top stone step on the wing wall south end of west abutment of P. R. R. stone arch bridge over Branch of Pensauken Creek," about one-half mile west of station.

E SHADE. **Eleva., 40.57 ft.**
oss on the south end of door sill of entrance, on the east face, to school building, about 200 yards south of the railroad track, just f the P. R. R. Station.

E SHADE. **Eleva., 23.20 ft.**
oss on the southwest corner at the west end of north concrete t of P. R. R. bridge over "North Branch of Pensauken," about ile east of station (or one-quarter mile west of Lenola station). oss is slightly above and 6 feet from the rail.

TON. **Eleva., 91.23 ft.**
er bolt in stone monument at the west end of platform of the rail- tation south of the track.

TON. **Eleva., 108.57 ft.**
oss on the topmost point of boulder at the northeast corner of the oads at the hotel.

TON. **Eleva., 108.76 ft.**
oss on the west end of granite sill of small basement window on rth face and near the northwest corner of Marlton school, a brick re 100 yards south of the crossroads.

NVILLE. **Eleva., 46.10 ft.**
oss on the northwest corner of concrete base of signal, about 100 west of P. R. R. station, and on the north side of the track.

MASONVILLE. **Eleva., 19.46 ft.**
A cross on the southwest corner of large stone and on the level of the girder seat, at the south end of east abutment of P. R. R. bridge over Mason's Creek, about three-quarters of a mile east of station.

MEDFORD. **Eleva., 32.39 ft.**
A cross on the outer edge and in the center of cement cap of east parapet of railroad culvert over Sharps Run about one-half mile northeast of the station.

MEDFORD. **Eleva., 52.02 ft.**
A cross immediately at the southwest corner of brick work on the concrete base of chimney of the gas factory at the railroad station.

MEDFORD. **Eleva., 39.39 ft.**
A cross one foot above the sidewalk on the southwest corner at the extreme southerly end of west parapet of concrete highway bridge over Sharps Run about 300 yards north of the railroad station.

MEDFORD. **Eleva., 64.70 ft.**
A cross 3.66 feet above the sidewalk on the water table at the northwest corner of Bank at Main and Union Streets.

MOORESTOWN. **Eleva., 62.63 ft.**
A copper bolt on the west end of brown stone door sill of the entrance to waiting room, on the north face of West Moorestown station.

MOORESTOWN. **Eleva., 71.40 ft.**
A cross on the outer corner at the westerly end of door sill of boys entrance on the northerly face of High School. The building is on North Church Street, about 200 yards southerly from the West Moorestown railroad station. The cross is the same elevation as the stone base course of the structure.

MOORESTOWN. **Eleva., 75.45 ft.**
A cross on the white sandstone water-table, 3.2 ft. above the ground and in the center of the front of "Relief Fire Engine" house, on the west side of Chester Avenue, about 200 feet southerly from the P. R. R. tracks.

MOORESTOWN. **Eleva., 79.44 ft.**
A copper bolt on the west end of door sill of the waiting room entrance to Stanwick Avenue station.

MOUNT HOLLY. **Eleva., 12.74 ft.**
A cross on the outer edge at the east end of door sill of most westerly

MOUNT HOLLY. Eleva., 42.96 ft.
On the northwest corner of marble door sill of main entrance to Burlington County Court House.

MOUNT HOLLY. Eleva., 62.24 ft.
A copper bolt on the north end of east pier holding frame support of bridge over Burlington Branch of P. R. R. at Fair Grounds in the northern part of the city.

MOUNT HOLLY. Eleva., 185.47 ft.
On the northwest corner of granite monument, located on the summit of Mount Holly, and which marks the U. S. Coast and Geodetic Survey triangulation point, Mount Holly.

PALMYRA. Eleva., 19.79 ft.
A cross on the outer edge at the extreme westerly end of door sill of Fifth Street entrance to "Sunday School Temple" of "Epworth M. E. Church" on the corner of Fifth Street and Morgan Avenue. The entrance is about 100 feet westerly from Morgan Avenue.

PALMYRA. Eleva., 21.71 ft.
A cross on the outer corner at the easterly end of door sill of baggage room entrance on south face of P. R. R. station. The building is on the westerly side of the tracks.

PALMYRA. Eleva., 23.81 ft.
A cross on the outer corner at the southerly end of the door sill of third entrance from the northwest corner, on the southwest face of "P. O. S. A. Hall," opposite the P. R. R. station.

PALMYRA. Eleva., 23.44 ft.
A cross on the westerly end of brown stone window sill of the most westerly basement window on the north face of Palmyra Public School. The structure is of red brick and is at the forks of the road, about 200 yards southerly from the P. R. R. station.

PALMYRA. Eleva., 14.10 ft.
A cross on the southeast corner of a large stone on the southerly end of northeast abutment of P. R. R. bridge over Pensauken Creek, about one mile westerly from the station. The cross is on the level of the girder seat and is 4 feet from the girder.

PEMBERTON. Eleva., 51.81 ft.
Copper bolt on the northerly end of door sill of entrance to baggage room on the west face of the railroad station.

PEMBERTON. Eleva., 78.24 ft.
A cross on the outer corner at the west end of sill of double door entrance on the southerly face of the M. E. Church on the east side of the main street.

PEMBERTON. Eleva., 77.30 ft.
A cross on the outer corner at the southerly end of door sill of the front entrance to the First Baptist Church on the westerly side of the main street.

PEMBERTON. Eleva., 57.04 ft.
A cross on the outer corner at the northerly end of brown sandstone door sill of main entrance to the Peoples National Bank on the easterly side of the main street northerly from the bridge over the pond at South Pemberton.

PEMBERTON. Eleva., 76.05 ft.
On the southwest or outer corner of brown sandstone base of the most northerly of two columns at the main entrance to the Pemberton High School two blocks easterly from the M. E. Church. The elevation is about the same as the cement door sill.

REEVES STATION. **Eleva., 28.24 ft.**

A cross on the topmost point at the center of cement cap of eas erly parapet of railroad culvert about one-quarter mile southerly fro the station near milepost "5-2".

RIVERSIDE. **Eleva., 22.70 ft.**

On the outer corner at the westerly end of door sill of the mai entrance to the offices of the Keystone Watch Co. The building is jus above the P. R. R. station on the westerly side of the track.

RIVERSIDE. **Eleva., 24.60 ft.**

A cross on the outer corner at the easterly end of door sill of Sco Street entrance to Riverside National Bank, about 200 ft. westerly fro Pavilion Avenue.

RIVERSIDE. **Eleva., 25.05 ft.**

A cross on the outer corner at the westerly end of door sill of Sco Street entrance to Riverside Turncemeinde, a red brick building abo 100 yards westerly from Pavilion Avenue.

RIVERSIDE. **Eleva., 19.78 ft.**

A cross on the outer corner at the easterly end of brown stone do sill of corner entrance on Scott Street to W. F. Taubel, Inc. Co.'s kni ting mill and offices. The structure built of yellow brick, is on th southerly side of the railroad track at the east corner of Scott Stre and Fairview Avenue.

RIVERTON. **Eleva., 7.49 ft.**

A cross on the northeast corner of concrete block at the souther end of westerly abutment of P. R. R. bridge over stream about on quarter mile northeast of station. The cross is about four and on half feet below the rail.

RIVERTON. **Eleva., 21.14 ft.**

A cross on the outer corner at the northeast end of cement door si of rear entrance, on the northwest face of store of J. S. Collins & So Inc., opposite the P. R. R. station and on the southerly side of the trac

RIVERTON. **Eleva., 15.34 ft.**

A cross on the outer edge of the southwest end of granite door si of Fourth Street entrance to Public School, a brick building on th north corner of Howard Avenue and Fourth Street.

RIVERTON. **Eleva., 16.83 ft.**

SMITHVILLE. **Eleva., 24.77 ft.**

A cross just below the north end of the northwest wingwall of bridge on the southwest corner of west retaining wall along the roadway north of the highway bridge over North Branch of Rancocas Creek about 0.3 miles north of the railroad station.

SMITHVILLE. **Eleva., 45.18 ft.**

A cross on a ledge of foundation stone 2.2 feet below the lower edge of the first course of brick at the northeast corner and on the north face of a three-story structure on the west side of the highway and north of the track at the railroad station.

STEVENS. **Eleva., 23.97 ft.**

A cross on the southwest corner of concrete base of signal, about 200 yards easterly from the P. R. R. station and on the north side of the track.

WHITE HILL—see FIELDSBOROUGH.

WRIGHTSTOWN. **Eleva., 137.00 ft.**

A cross on the outer corner at the west end of door sill of the west double door entrance on the south face of creamery, a tile structure on the north side of the Pemberton and Hightstown Railroad 100 yards west of the station.

WRIGHTSTOWN. **Eleva., 148.30 ft.**

A cross on the outer corner at the east end of brown sandstone door sill of front entrance to the M. E. Church, a brick structure on the south side of the main street about 350 yards west from the Pemberton and Hightstown Railroad station.

WRIGHTSTOWN. **Eleva., 125.33 ft.**

A cross on the outer edge at the south end of door sill of the most northerly basement entrance to creamery on the west side of highway leading north to Trenton, about 75 yards north of the crossroads. The upper story of this building is of wood and the lower of red brick.

WRIGHTSTOWN. **Eleva., 121.54 ft.**

A cross directly over the center of arch and 2.47 feet below the top of east parapet on projection of floor of concrete highway bridge over "North Run" about 175 yards north of the crossroads.

WRIGHTSTOWN. **Eleva., 139.37 ft.**

On the outer corner at the south end of sandstone door sill of center entrance under the porch on the east face of dwelling belonging to J. Shreve, located on the southwest corner of Trenton Avenue and the main street. The house sets back somewhat from the side line of Trenton Avenue.

WRIGHTSTOWN. **Eleva., 153.63 ft.**

A cross on the southwest corner of the southwest concrete pier supporting steel column of railroad water tank 50 feet easterly from the Pemberton and Hightstown Railroad track about one-half mile southwest of the station.

SECONDARY BENCH MARKS.[1]

BEVERLY **35.0 ft.**

South rail of crossing west of station.

BIRMINGHAM. **34.9 ft.**

North rail of crossing at the station.

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[1] "Rail at station" means rail joint nearest the center of the station. "Rail at crossing" means rail joint; if there is none, the elevation is taken on the rail in the center of the roadway. Elevations are given to the nearest tenth of a foot, except when otherwise noted.

BROWN STATION. **48.2 ft.**
East rail of crossing at the station.

BROWN STATION. **48.7 ft.**
Bottom edge of baseboard at the northwest corner of dwelling on the south side of the highway east of the station.

BROWN STATION. **42.9 ft.**
East rail of highway crossing 0.7 mile south of the station.

CAMBRIDGE. **16.3 ft.**
Rail at station.

COOKSTOWN. **90.2 ft.**
North rail of crossing about 300 yards east of the station.

COOKSTOWN. **97.5 ft.**
Bottom edge of baseboard at the southwest corner of the hotel near the railroad station.

COOKSTOWN. **80.73 ft.**
West end of concrete spillway wall at the southwest corner of the grist mill. The spillway is from the channel leading to the wheel.

COOKSTOWN. **98.7 ft.**
North rail of crossing at the station.

CROPWELL STATION. **80.8 ft.**
South rail of crossing at the station.

CROPWELL STATION. **75.5 ft.**
Southerly rail of crossing 0.35 miles west of the station.

DEACON. **74.8 ft.**
Rail at station.

DELANCO. **13.9 ft.**
Rail at station.

EDGEWATER PARK. **30.1 ft.**
Rail at station.

ELMWOOD ROAD. **62.6 ft.**
South rail of crossing one-half mile east of the station.

ELMWOOD ROAD. **64.0 ft.**
South rail of crossing at the station.

EWANSVILLE. **55.4 ft.**
South rail of crossing one-half mile east of the station.

STOWN. **85.7 ft.**
erly rail of crossing of the Camp Dix branch of the Pennsylvania
ad and the Juliustown highway, northerly from the crossroads.

STOWN. **86.2 ft.**
heast rail of crossing of the Camp Dix branch and the Wrights-
emberton concrete highway.

STOWN. **86.2 ft.**
t of frog of the southwest Y of junction of Kinkora and Camp Dix
es at the station.

ERTON. **30.8 ft.**
erly rail of diagonal crossing 0.3 mile north of the station.

ERTON. **15.8 ft.**
rail of crossing at the station.

ERTON. **36.1 ft.**
rail of crossing three-quarters mile south of the station.

TON. **94.3 ft.**
th rail of crossing of main track just east of the station.

TON. **88.50 ft.**
oss on the southeast corner of concrete base of signal on the south
f the track 125 yards west of the station.

TON. **87.2 ft.**
th rail of crossing about 300 yards west of the station.

NVILLE. **46.5 ft.**
l at station.

ORD. **50.0 ft.**
th rail of crossing at the station.

OSE. **58.7 ft.**
th rail of crossing about one-half mile east of the station.

OSE. **64.4 ft.**
of concrete foundation at the southeast corner of the station.

OSE. **63.9 ft.**
l of diagonal crossing at the station.

YRA. **20.9 ft.**
th rail of crossing at station.

YRA. **15.3 ft.**
l at Arch Street station.

ERTON. **50.0 ft.**
l at the station.

ERTON. **44.7 ft.**
therly rail of crossing at South Pemberton station.

INS. **19.6 ft.**
th rail at the crossing.

ES STATION. **43.3 ft.**
t rail of crossing at the station,

RSIDE. **17.4 ft.**
th rail of crossing at the station.

RTON. **17.4 ft.**
th rail of crossing at the station.

LING. **30.2 ft.**
l at station.

VE STATION. **84.62 ft.**
ss on the concrete base of signal on the southeast side of the rail-
about 250 yards northeast of the station.

SHREVE STATION. **84.1 ft**
Southeast rail of crossing at the station.

SMITHVILLE. **48.83 ft**
A cross next to building on the west end of cement step at entra to waiting room on the south face of the station.

SMITHVILLE. **47.9 ft**
South rail of crossing at the station.

SMITHVILLE. **41.7 ft**
South rail of crossing one mile west of the station.

STEVENS. **24.3 ft**
South rail of crossing at the station.

TAYLOR. **16.0 ft**
Rail at station.

WILKINS STATION. **59.4 ft**
East rail of crossing at the station.

WOOD LANE. **56.1 ft**
West rail of crossing at the station.

WRIGHTSTOWN. **134.0 ft**
Northwest rail of crossing at the Pemberton and Hightstown Railro station.

WRIGHTSTOWN. **135.2 ft**
North rail of crossing of Pemberton and Hightstown Railroad 175 ya southwest of the station.

WRIGHTSTOWN. **126.4 ft**
North rail of crossing one and one-half mile northeast of the stati

CAMDEN COUNTY.[1]

ANCORA. **Eleva., 95.27 ft**
Copper bolt 3.8 feet from the rail on the east end of south stone ab ment of old railroad bridge over brook about 300 yards north of t station.

ANCORA. **Eleva., 99.92 ft**
A cross on the southwest corner of stone on the south end of east p supporting steel frame of overhead highway bridge at the station.

ATCO. **Eleva., 148.22 ft.**
Copper bolt in stone monument on the easterly side of the tracks about ten yards northerly from the north face of the Pennsylvania Railroad station.

ATCO. **Eleva., 142.14 ft.**
On the outer corner at the southerly end of brick sill of window on the easterly face and at the northeast corner of a one-story brick structure used as a broom factory on the westerly side of the Pennsylvania Railroad tracks about 200 yards southerly from the station.

ATCO. **Eleva., 151.77 ft.**
A cross on the outer corner at the south end of brown sandstone door sill of entrance under the alcove on the easterly face and at the southeast corner of a public school building about two blocks southwest of the railroad station.

ATCO. **Eleva., 125.59 ft.**
A cross one foot from the girder on the northwest corner of bridge seat at the westerly end of south abutment of highway bridge on the easterly side of the railroad about one-half mile south of the station. The road is parallel to the track and is the approach to an overhead bridge.

BERLIN. **Eleva., 156.57 ft.**
A cross on the outer corner at the south end of door sill of rear entrance to the public school, a red-brick and brownstone structure, on the east side of the main street northwest of the railroad station.

BERLIN. **Eleva., 170.68 ft.**
On the outer corner at the south end of cement door sill of entrance to the Berlin National Bank opposite the hotel.

BERLIN. **Eleva., 168.25 ft.**
A cross slightly above the cement sidewalk on the northeast corner of stepping stone in front of the Berlin Hotel.

BERLIN. **Eleva., 168.41 ft.**
On the outer corner at the north end of cement door sill of entrance under the tower to the Baptist Church, a brown stone structure on the easterly side of the main street.

BERLIN. **Eleva., 166.14 ft.**
A cross on the southwest corner at the southerly end of east stone pier supporting steel frame of the first overhead highway bridge about one-quarter mile southerly from the railroad station.

BISHOPS BRIDGE. **Eleva., 158.00 ft.**
A cross on ledge of stone on the southerly end and at the southeast corner of the westerly stone pier on which rests the steel frame of overhead highway bridge about 300 yards northerly from the station.

CAMDEN. **Eleva., 20.22 ft.**
A cross on the northeast end of basement window sill and near the stone bearing date of 1913, at the northwest corner of N. G. N. J. armory on Wright Avenue, about 400 yards northeast of the City Hall.

CAMDEN. **Eleva., 30.44 ft.**
A cross on the outer corner at the northerly end of granite door sill, Haddon Avenue entrance to City Hall.

CAMDEN. **Eleva., 24.75 ft.**
A cross on the outer corner at the north end of sand stone door sill of most northerly entrance on 6th Street to the First M. E. Church, opposite Cooper Hospital.

CAMDEN. **Eleva., 19.09 ft.**
A cross on the outer edge and six inches above sidewalk at the north end of granite step of entrance to P. R. R. station and outbound electric trains, on Broadway.

CAMDEN. **Eleva., 28.42 ft.**
A cross on granite base supporting columns and on the extreme right of Federal Street entrance to Y. M. C. A. near Broadway. The cross is three feet above the sidewalk and on the face of the building.

CAMDEN. **Eleva., 29.90 ft.**
A cross on outer corner, at the west end of large stone slab and door sill of most westerly entrance on Federal Street to Court House.

CAMDEN. **Eleva., 29.94 ft.**
A cross on the south end of westerly bridge pier supporting concrete columns of overhead highway bridge at Pavonia station of Penn. R. R. The cross is at the outer corner of beveled end of pier, and measures 1.2 feet from face of nearest column.

CAMDEN. **Eleva., 24.40 ft.**
A square cut on the base course at the southeast corner of boiler house of the P. R. R. shops at Pavonia station. The square is about one foot below the present surface of the ground.

CAMDEN. **Eleva., 21.96 ft.**
A square cut on the base course at the southeast corner of planing mill of P. R. R. shops at Pavonia station.

CAMDEN. **Eleva., 30.84 ft.**
On easterly corner of pedestal, over the builders' names (Krips & Shearman), of the Soldiers' Monument, on Haddon Avenue, just north of City Hall.

COLLINGSWOOD. **Eleva., 29.31 ft.**
A cross cut in the northwest foundation bolt of steel standpipe of city water supply near the railroad station. The bolt is the first to the left of the manhole at the base of the standpipe.

COLLINGSWOOD. **Eleva., 28.35 ft.**
A cross on the outer corner at the west end of cement door sill of entrance under the tower to fire house north of the railroad station.

COLLINGSWOOD. **Eleva., 39.17 ft.**
A cross on the outer corner at the east end of marble door sill of the most westerly single door entrance to the Collingswood National Bank on Haddon Avenue opposite Irving Ave.

COLLINGSWOOD. **Eleva., 37.69 ft.**
A cross on the north end of sill of small basement window on the east side of the Haddon Avenue annex and on the left of main entrance to Public School No. 1—at Irving Avenue.

COLLINGSWOOD. **Eleva., 31.13 ft.**
A cross on the outer corner at the southeast end of brown sandstone

FISHER. Eleva., 127.23 ft.

Copper bolt in monument at the railroad station.

FISH HOUSE. Eleva., 15.97 ft.

A cross on the level of the girder seat and on the southeast corner of large stone on the east end of north abutment of P. R. R. bridge over roadway just below the station. The cross is seven feet from the girder.

FREEMAN STATION. Eleva., 36.49 ft.

A cross cut in ledge of stone on the east face, sixteen feet from the north end, and 1.35 feet below the top of west parapet of highway bridge over Tindale Run, 75 yards north of the station.

GLOUCESTER. Eleva., 17.46 ft.

Copper bolt in the south end of door sill of the most northerly entrance on the east face of the railroad station.

GLOUCESTER. Eleva., 20.54 ft.

A cross on the outer corner at the easterly end of brown sandstone door sill of entrance on the south face of Gloucester High School, a brick structure at the junction of Broadway and Monmouth Streets.

GLOUCESTER. Eleva., 20.17 ft.

A cross on the outer edge at the east end of door sill of Monmouth Street, entrance to the City Hall, 75 yards easterly from Burlington Street.

GLOUCESTER. Eleva., 15.80 ft.

A cross on the outer corner at the east end of granite door sill of Monmouth Street entrance to the Presbyterian Church at Burlington Street.

GLOUCESTER. Eleva., 15.59 ft.

A cross on the outer corner at the westerly end of marble door sill of Monmouth Street entrance to the M. E. Church, 75 yards easterly from King Street.

GLOUCESTER. Eleva., 7.78 ft.

A cross next to the building at the southwest end of marble slab at the entrance on the northwest corner of Buena Vista Hotel near the ferry slip.

HADDONFIELD. Eleva., 49.01 ft.

A cross 6.7 feet north of the girder on the northwest corner of bridge seat at the north end of east abutment of P. R. R. bridge (Medford Br.) over Coopers Creek about three-quarters mile southeast of the station.

HADDONFIELD. Eleva., 79.85 ft.

A cross on the outer corner at the south end of door sill of the most southerly entrance on the east face of Haddonfield High School at Lincoln Avenue and Chestnut Street.

HADDONFIELD. Eleva., 66.36 ft.

A cross on the outer corner at the west end of door sill of entrance to the Haddonfield National Bank on Kings Highway East, near Tanner Street.

HADDONFIELD. Eleva., 69.86 ft.

A cross on the outer corner at the north end of brown standstone door sill of tower entrance on the west face of the First Baptist Church on Kings Highway East, near Tanner Street.

HADDONFIELD. Eleva., 71.46 ft.

A cross 0.65 feet from the outer edge and one foot from the west end of brown sandstone door sill of entrance to alcove on the southerly face of Grace Church on the northerly side of Kings Highway East, near the railroad station.

HADDONFIELD. **Eleva., 76.73 ft.**
A cross in the center of blue sandstone coping at the north end stairway of the east platform at the railroad station.

KIRKWOOD. **Eleva., 68.61 ft.**
A cross on the southeast corner at the south end of stone cap of we pier on which rests the steel frame of overhead highway bridge at th railroad station.

KIRKWOOD. **Eleva., 67.06 ft.**
A cross on the southeast corner of lowest stone step at the south en of west abutment of highway bridge over the railroad at the station.

KIRKWOOD. **Eleva., 59.46 ft.**
A cross on the southwest corner of bridge seat at the west end of north abutment of bridge over spillway at the south end of dam of pond opposite the railroad sation.

KIRKWOOD. **Eleva., 60.04 ft.**
A cross on southeast corner of slate slab on south side of outlet of pond, on dam opposite railroad station. (The mark is 8.5 ft. southerly from face of the southerly abutment.)

KIRKWOOD. **Eleva., 65.17 ft.**
A cross on the northeast corner of lowest stone step at the easterly end of the northeast wing wall of southerly parapet of highway culvert over Coopers Creek near the dam opposite the railroad station,

LINDENWOLD. **Eleva., 108.47 ft.**
A cross in uppermost cap stone of sloping wing wall at the northeast end of northwest abutment of railroad bridge over highway about one-half mile southeast of the station. The mark is 1.9 feet below the concrete beam to which a galvanized iron railing is attached.

LUCASTON. **Eleva., 134.99 ft.**
A cross on the southwest corner of stone on the southerly end of northeast pier supporting steel frame of overhead highway bridge at the station

MERCHANTVILLE. **Eleva., 37.44 ft.**
A cross on the northwest corner of concrete base of signal at crossin about one-half mile west of Wellwood station, and on the southerl side of the P. R. R. track.

MERCHANTVILLE. **Eleva., 80.50 ft.**
A copper bolt at the west end of marble door sill, main entrance t

ORCHARD. **Eleva., 69.70 ft.**

Copper bolt in stone monument about 20 feet west of railroad station and south of the track.

OSAGE. **Eleva., 60.39 ft.**

A cross on the center of east parapet of railroad culvert about 300 yards south of the station.

SICKLERVILLE. **Eleva., 142.59 ft.**

A cross on the outer corner on the northeast end of brick window sill of large window on the westerly face and near the northwest corner of a brick structure used as a garage, on the southeast corner of the crossroads about 200 yards northwest of the railroad station.

SICKLERVILLE. **Eleva., 152.64 ft.**

Top of concrete foundation at the southeast corner of public school building on the northerly side of the Turnersville road about one-third mile northwest of the railroad station.

SPRINGDALE. **Eleva., 64.41 ft.**

Copper bolt in stone monument at the northeast corner of the railroad station.

WATERFORD. **123.34 ft.**

Copper bolt in monument on the west platform of the railroad station.

WATERFORD. **Eleva., 110.31 ft.**

A cross near the southeast corner, 3.6 feet above the rail at the south end of west abutment of highway bridge over the railroad about three-quarters mile south of the station.

WEST BERLIN. **Eleva., 164.59 ft.**

A cross on the southwest corner at the southerly end of the northeast stone pier supporting steel frame of overhead highway bridge about one-quarter mile northwest of the railroad station.

WEST BERLIN. **Eleva., 174.93 ft.**

A cross on the outer corner at the easterly end of cement door sill of entrance on the southerly face of public school building northeast of the railroad station.

WEST BERLIN. **Eleva., 174.49 ft.**

Top of concrete foundation at the northwest corner of public school building northeast of the railroad station.

WILLIAMSTOWN JUNCTION. **Eleva., 156.77 ft.**

A cross on the northeast corner of concrete wall of scale pit 150 yards northeast of the main line of the Reading Railroad, 0.2 mile southeast of the station.

WILLIAMSTOWN JUNCTION. **Eleva., 151.85 ft.**

A cross on the southeast corner of concrete base of signal on the west side of the main line of the Reading Railroad and east of the Y connection with the Mullica Hill Branch about 175 yards southeast of the station.

WINSLOW. **Eleva., 121.15 ft.**

A cross on the northeast corner of bridge seat at the easterly end of north abutment of Pennsylvania Railroad bridge over highway about one-quarter mile northwest of the Pennsylvania station.

WINSLOW. **Eleva., 121.24 ft.**

Copper bolt on bridge seat at the easterly end of northwest abutment of Pennsylvania Railroad bridge over the New Jersey Central Railroad at the Pennsylvania station.

WINSLOW. Eleva., 112.019 ft.

Elevation of underground mark 107.779

This monument (No. 18) is located in the grass plot, 22.5 feet west of flag pole. It is in the center line of road running south of New Jersey Southern Railroad station, and is about in center line of roads running to Hammonton and Waterford. The following measurements were taken from the monument: north 46° 30′ east, 57 feet to large oak; north 6° 30′ west, 41 feet to another large oak; 123.25 feet to southeast corner of Hay & Co.'s store; 50 feet to corner of glass works fence; 55 feet perpendicularly to south line of road to New Germany; 58 feet to southwest street corner, and 73 feet to northeast corner of house on this southwest corner.

YORKSHIP. Eleva., 15.32 ft.

A cross next to the building on the north end of top cement step on slab at the front entrance to the U. S. Naval Inspection Office of the N. Y. Shipbuilding corporation at the railroad station.

YORKSHIP. Eleva., 14.39 ft.

A cross on the northwest corner of lower concrete base of the most northerly pier of two piers supporting signal frame on the east side of the tracks just north of the railroad station.

CAMDEN COUNTY.

SECONDARY BENCH MARKS.[1]

ANCORA. 95.2 ft.

Rail at the station.

ANCORA. 97.2 ft.

Top of concrete foundation at the northwest corner of the station.

ANDREWS. 122.1 ft.

The most southerly joint of the easterly rail on Reading Railroad bridge over Great Egg Harbor River one mile northeast of the station.

ANDREWS. 128.9 ft.

Point of frog of siding southwest of station.

ANDREWS. 127.6 ft.

Northwest rail of crossing at the station.

ASHLAND. 72.7 ft.

BERLIN.	153.8 ft.
Rail at Reeds Crossing station.	
BERLIN.	171.85 ft.
Next to the building on the center of cement cap of low wall on the left side of the steps at the front entrance to the Berlin National Bank.	
BERLIN.	159.6 ft.
West rail of crossing 50 feet southeast of the station.	
CAMDEN.	10.4 ft.
East rail of crossing at South Camden station.	
CAMDEN.	8.19 ft.
A cross on the southeast corner of the most southerly of two concrete piers supporting signal frame on the west side of the N. J. & S. R. R. tracks at the junction about one-quarter mile northerly from South Camden station.	
CAMDEN.	15.3 ft.
East rail of crossing at Kaighn Avenue station.	
CHESILHURST.	117.7 ft.
East rail of crossing at the station.	
CHESILHURST.	118.64 ft.
Bottom edge of corner strip at the northeast corner of large frame structure on the west side of the railroad and north of the highway at the station.	
CUTHBERT.	39.41 ft.
A cross on the northwest corner of concrete base of signal on the westerly side of the railroad southeast of the station.	
CUTHBERT.	36.1 ft.
West rail of north track of crossing at the station.	
DELAIR.	23.4 ft.
Rail at station.	
DUNBARTON.	124.7 ft.
Rail at station.	
FISHER.	128.09 ft.
Next to the building on the west end of cement porch floor of brick dwelling on the east side of the railroad and on the north side of highway 150 yards north of the station.	
FISHER.	125.6 ft.
Rail at station.	
FISH HOUSE.	17.8 ft.
Rail at station.	
FREEMAN STATION.	38.2 ft.
North rail of crossing one and one-quarter miles east of Haddonfield on the Medford Branch of the Pennsylvania Railroad.	
FREEMAN STATION.	38.93 ft.
A cross on the southwest corner of upper concrete block on which rests warning signal of approaching trains, on the north side of the track and east of the road at the station.	
GLOUCESTER.	18.7 ft.
East rail of crossing at South Gloucester station of the W. J. & S. Railroad	
GLOUCESTER.	16.8 ft.
East rail of crossing 30 yards north of the W. J. & S. Railroad station.	

GLOUCESTER. **12.4 ft.**
Northeast frog of east crossing of the W. J. & S. Railroad and the Mt. Ephraim Branch of the Reading Railroad about 0.3 mile north of the Pennsylvania station.

HADDONFIELD. **64.5 ft.**
Northeast rail of crossing at West Haddonfield station.

LINDENWOLD. **93.8 ft.**
Bottom of baseboard at the southeast corner of Stack's store diagonally opposite the railroad station.

LINDENWOLD. **93.2 ft.**
Northeast rail of crossing at the station.

LOCUST GROVE. **92.2 ft.**
South rail of crossing at the station.

LUCASTON. **130.0 ft.**
Rail at the station.

MAPLE SHADE. **41.0 ft.**
Rail at the station.

MORRIS. **13.5 ft.**
Rail at the station.

ORCHARD. **68.9 ft.**
South rail of diagonal crossing at the station.

OSAGE. **72.42 ft.**
A cross on the southwest corner of lower block of concrete on which rests signal for trains on the east side of the railroad about 250 yards north of the station.

OSAGE. **71.3 ft.**
West rail of north bound track of crossing at the station.

PENSAUKEN. **69.6 ft.**
Rail at station.

SICKLERVILLE. **139.9 ft.**
Southerly rail of crossing at the station.

SICKLERVILLE. **140.0 ft.**
Point of frog of siding just west of crossing at the station.

SICKLERVILLE. **149.18 ft.**
On the southeast end of small basement window sill on the westerly face and near the southeast corner of public school building.

WEST BERLIN. **166.9 ft.**
Northeast rail of crossing at the station.

WESTMONT STATION. **50.9 ft.**
Rail of eastbound track at the station.

WILLIAMSTOWN JUNCTION. **168.6 ft.**
North rail of crossing about 0.3 miles northeast of the station on the Atco branch of the Reading Railroad.

WILLIAMSTOWN JUNCTION. **147.9 ft.**
Point of frog connecting Y's of the Mullica Hill Branch, 200 yards southwest of the main line of the Reading railroad.

WOODCREST STATION. **51.4 ft.**
Northeast rail of crossing at the station.

YORKSHIP STATION. **13.8 ft.**
East rail of crossing just north of the station.

YORKSHIP. **14.3 ft.**
Northeast frog of crossing of W. J. & S. and Reading railroad tracks just north of the station.

CUMBERLAND COUNTY.[1]

BRIDGETON. **Eleva., 46.39 ft.**
A cross on the outer corner at the northeast end of sandstone door sill of entrance on the easterly face of Irving Avenue station, W. J. & S. Railroad.

BRIDGETON. **Eleva., 45.48 ft.**
A cross 13 feet from the southeast corner of building and 3 feet above the ground on a ledge of foundation stone on the southwest face of Irving Avenue Public School, 70 yards westerly from the railroad station.

BRIDGETON. **Eleva., 28.17 ft.**
A cross on the northeast corner of concrete slab at the waste gates at the southeast corner of East Lake on the northerly side of East Commerce Street.

BRIDGETON. **Eleva., 38.44 ft.**
A cross on the southwest corner of stone base of the most westerly column of porch of main entrance to the Post Office on the corner of East Commerce and Bank Streets.

BRIDGETON. **Eleva., 32.73 ft.**
A cross on the outer corner at the northerly end of door sill of entrance under the tower and on the easterly face of Central M. E. Church on the corner of East Commerce and Bank Streets.

BRIDGETON. **Eleva., 22.41 ft.**
This bench mark is a cross cut on east end of door sill of main front entrance of First Baptist Church, on Commerce Street.

BRIDGETON. **Eleva., 14.71 ft.**
On the outer edge, 2.2 feet from the westerly end of door sill of East Commerce Street entrance to the Cumberland Trust Company's building at Pearl Street.

BRIDGETON. **Eleva., 54.25 ft.**
This bench mark is a cross cut on west end of large upper stone step of front entrance of stone Presbyterian Church, on Commerce Street, in West Bridgeton.

BRIDGETON. **Eleva., 47.58 ft.**
A cross on the outer corner at the westerly end of granite door sill of main entrance to the Cumberland County Court House on Broad Street.

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[1] Supersedes all previous lists for this county.

BRIDGETON. **Eleva., 10.54 ft.**
A cross on the west end of window sill of the most westerly window the southerly face of the pumping station of the Bridgeton Water Wor in the park, just north of Commerce Street.

BRIDGETON, NEAR. **Eleva., 87.39 ft.**
A cross on the northwest corner of concrete base of signal on t westerly side of the West Jersey and Seashore Railroad track about yards southwest of the crossing of the Central Railroad, about two mil north of Bridgeton.

FINLEY. **Eleva., 108.05 ft.**
Copper bolt in monument at southeast corner of the railroad station.

HUSTED. **Eleva., 88.60 ft.**
A cross on the topmost point of bell at the westerly end of concret pipe culvert under the railroad about 0.35 mile northerly from the statio

HUSTED. **Eleva., 97.92 ft.**
A cross on the southeast corner of concrete base of signal on the eas side of the railroad about 80 yards northerly from the station.

HUSTED. **Eleva., 99.55 ft.**
A cross on the southwest corner of concrete wall around well and pum at the north face of the station.

HUSTED. **Eleva., 98.56 ft.**
Copper bolt in monument at the southeast corner of the railroad station

NORTH VINELAND. **Eleva., 98.21 ft.**
A cross on the southeast corner of concrete wall around well and pum at the south end of the railroad station.

NORTH VINELAND. **Eleva., 80.26 ft.**
A cross 1.8 feet from the girder on the outer corner of bridge seat a the east end of south abutment of West Jersey and Seashore Railroa bridge over Blackwater Branch about 0.8 mile south of station.

MILLVILLE. **Eleva., 33.45 ft.**
This bench mark is a cross cut on the water table on southwest corne of Millville Public Library, on northeast corner Main and Second Streets

MILLVILLE. **Eleva., 28.79 ft.**
This bench mark is a cross cut on east end of stone door sill of mai entrance to Workingmen's Institute.

VINELAND. **Eleva., 112.50 ft.**
A cross on the outer corner at the south end of brown sandstone windo

VINELAND. **Eleva., 115.74 ft.**
This bench mark is a cross cut on east end of stone door sill of entrance to First M. E. Church, on northeast corner of Landis Avenue and Seventh Street.

VINELAND. **Eleva., 118.00 ft.**
This bench mark is a cross cut on east end of front or north door sill of First Baptist Church, on south side of Landis Avenue.

SECONDARY BENCH MARKS.[1]

BRIDGETON. **44.7 ft.**
Westerly rail of crossing at Irving Avenue station of the Pennsylvania Railroad.

BRIDGETON. **68.7 ft.**
Northwesterly rail of Pennsylvania Railroad at diagonal crossing about one-half mile south of the crossing of the Pennsylvania and Central Railroads north of Bridgeton.

BRIDGETON. **91.5 ft.**
Southeast frog of crossing of the West Jersey and Seashore Railroad and the Central Railroad about two miles north of Bridgeton.

FINLEY. **116.0 ft.**
Westerly rail of crossing just north of mile post 33-6, between Husted and Finley stations.

FINLEY. **104.4 ft.**
Westerly rail of crossing about three-quarters of a mile north of station.

FINLEY. **113.9 ft.**
Point of frog of siding into Seabrook farm about 0.35 mile north of the station.

FINLEY. **109.6 ft.**
Easterly rail of crossing at the station.

FINLEY. **109.4 ft.**
Point of frog of siding 50 feet south of station.

FINLEY. **103.6 ft.**
Easterly rail of diagonal crossing, three-quarters of a mile southerly from the station.

HUSTED. **97.1 ft.**
East rail of diagonal crossing 0.3 mile northerly from the station.

HUSTED. **98.9 ft.**
West rail of crossing on north side of station.

HUSTED. **100.8 ft.**
West rail of crossing 200 yards south of the station.

NORTH VINELAND. **97.3 ft.**
West rail of crossing at the station.

ESSEX COUNTY.[2]

BELLEVILLE. **Eleva., 32.97 ft.**
A cross cut east of the iron fence, nearly in the center of the first coping stone, at the south end of the west parapet of the bridge which carries Washington Avenue over Second Street.

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[1] "Rail at crossing" refers to rail joint, if there is no rail joint at crossing. Elevation is taken on top of rail in center of roadway.

[2] Supersedes all previous lists for Essex County.

BELLEVILLE. **Eleva., 111.63 ft.**
A cross cut in the east corner of the sill of the first window west of the main entrance to Montgomery School No. 2, which stands on the north side of Montgomery Avenue, about 500 feet east of the bridge which carries said avenue over the Morris Canal.

BEAUFORT (STATION). **Eleva., 209.96 ft.**
A cross on the cement platform at the northwest corner of the Morristown and Erie Railroad station.

BEAUFORT (STATION). **Eleva., 230.83 ft.**
A cross 1.1 feet below the rail on the northwest corner at the north end of concrete abutment of the Morristown and Erie Railroad bridge over highway about .35 mile east of the station.

BEAUFORT (STATION). **Eleva., 219.52 ft.**
A cross 40 feet south of the rail on the highest point at the south end of a large circular culvert under the Morristown and Erie Railroad about 0.4 mile east of the station. The culvert is about 200 feet east of a highway.

BLOOMFIELD. **Eleva., 141.32 ft.**
A cross cut in the west end of stone sill of the middle of the three front doors of the old Presbyterian Church.

BLOOMFIELD. **Eleva., 132.75 ft.**
A cross cut in the extreme northwest corner of a large flat stone in the north end of the east abutment, upon which rests the east end of the north truss of the iron bridge which carries the Greenwood Lake Branch of the Erie Railroad over the Morris Canal.

BLOOMFIELD. **Eleva., 181.19 ft.**
A cross cut in the northwest corner of the west abutment, about six feet four inches above the towpath, of the bridge carrying the first road north of plane No. 11 over the Morris Canal.

BLOOMFIELD. **Eleva., 183.88 ft.**
This bench mark is on the northeast corner of the west abutment of a bridge which carries a road over the Morris Canal about two and three-eighths miles north of the old Presbyterian Church. On this corner are two letters cut on the stone: "J. W." The point is on the "W." The west end of the north truss of the bridge rests upon this stone.

BLOOMFIELD. **Eleva., 177.52 ft.**
A cross cut in the lowest step of the north wing wall of the west

CALDWELL. Eleva., 407.68 ft.

A cross on the extreme northerly end of window sill of the first window from the street on the westerly face of Fire House, a brick structure on the southerly side of Roseland Avenue about 200 feet from Bloomfield Avenue.

CALDWELL. Eleva., 411.79 ft.

A cross on the outer corner at the north end of door sill of the tower entrance on the easterly face of the First Presbyterian Church.

CALDWELL. Eleva., 402.90 ft.

A cross immediately below the granite base of the north column on the outer corner at the north end of large door sill of the Bloomfield Avenue entrance to Citizens National Bank at 333 Bloomfield Avenue.

CALDWELL. Eleva., 412.93 ft.

A cross immediately below the stone base of north lamp-post on the outer corner at the north end of large stone door sill of the main entrance to the Caldwell National Bank on Bloomfield Avenue opposite Roseland Avenue.

CALDWELL. Eleva., 416.61 ft.

A cross on the outer edge at the center of bluestone sill of basement window at the right of the Bloomfield Avenue entrance to the Public Library near Roseland Avenue.

CALDWELL. Eleva., 433.48 ft.

A cross one foot out from the building and seven feet from the northwest corner, on flagstone coping of stairway leading to the basement of the Erie Railroad station. The mark is the same elevation as the top of the blue sandstone over the cellar door.

CALDWELL. Eleva., 473.69 ft.

A cross on the northwest corner of stone into which the foot-bolt of the west gate drops when open—at the south entrance near Bloomfield Avenue to grounds of the Essex County Prison east of the railroad station.

CEDAR GROVE. Eleva., 200.03 ft.

A cross seven feet from the girder on the southwest corner of the bridge seat at the south end of east concrete abutment of the Erie Railroad bridge over the highway just east of the station.

CEDAR GROVE. Eleva., 285.70 ft.

A cross on the center of the east concrete parapet of arch highway bridge over Peckmans Brook just east of the railroad station and south of the tracks.

CEDAR GROVE. Eleva., 200.82 ft.

A cross on the outer corner at the west end of blue sandstone door sill of double-door basement entrance on the north face of the annex to Cedar Grove Public School on the main street. 400 yards south of the railroad station.

CEDAR GROVE. Eleva., [illegible] ft.

A cross on the northeast corner of bridge seat at the north end of west abutment of Erie Railroad bridge over Peckmans Brook 200 yards east of the station.

EAST ORANGE. Eleva., [illegible] ft.

A cross cut in the extreme north end of the [illegible] stone step [illegible] (and fourth from the bottom [illegible] leading to the main entrance of the East Orange Free Public Library which stands on the southeast corner of Main Street and Munn Avenue.

EAST ORANGE. **Eleva., 179.02 ft.**
A cross cut in the southwest corner of the base of a polished column, standing on the right of the entrance to the Essex County Trust Company's building, which is on the southeast corner of Main Street and Arlington Avenue.

EAST ORANGE. **Eleva., 180.52 ft.**
A cross cut in the extreme southwest corner of the top step of the most westerly entrance to the First Reformed Church, which stands on the southeast corner of Main and Halstead streets This bench mark is vertically below the cross at the peak of the roof.

EAST ORANGE. **Eleva., 184.98 ft.**
A cross cut in the northwest corner of the base of the most westerly of four columns standing in front of the People's Bank, which is located at the southwest corner of Main and Prospect Streets.

ESSEX FELLS. **Eleva., 360.14 ft.**
A cross on the outer corner at the north end of bluestone door sill of entrance on the east face of E. Bault's store and dwelling, a cobblestone and shingle structure south of the Erie Railroad at the station.

ESSEX FELLS. **Eleva., 356.36 ft.**
A cross on the outer corner at the west end of the first cement step below the top of stairway leading to basement on the southerly side and at the southeast corner of the Erie Railroad station.

ESSEX FELLS. **Eleva., 362.28 ft.**
A cross seven feet from the girder on the southeast corner of bridge seat at the south end of west concrete abutment of Erie Railroad bridge over roadway about 500 feet easterly from the station.

ESSEX FELLS. **Eleva., 389.33 ft.**
A cross on the outer corner of the southerly end of sandstone door sill of front entrance on the west face of offices of the Essex Fells Electric Light and Water Company on the southeast corner of Oak Lane and Roseland Avenue. The entrance faces Oak Lane but is approached from the Avenue.

ESSEX FELLS. **Eleva., 392.34 ft.**
A cross near the outer edge six inches from the easterly end of bluestone door sill of Roseland Avenue entrance to the Borough Hall, near Oak Lane.

GLEN RIDGE. **Eleva., 194.63 ft.**

EWOOD. **Eleva., 118.40 ft.**
oss cut in the east end of the north wing wall of the east abut-
f the bridge which carries Oakland Avenue over the East Branch
way River.

EWOOD. **Eleva., 109.77 ft.**
oss cut in the west end of the coping of the north wing wall of
st abutment of the bridge which carries Baker Avenue over the
ranch of Rahway River.

EWOOD. **Eleva.. 133.86 ft.**
oss cut in the west end of the door sill, of the only entrance on
uth or rear side, to the first or main floor of the public school
g, which stands on the south side of Baker Avenue, just east of
laware, Lackawanna and Western Railroad.

EWOOD. **Eleva., 97.35 ft.**
oss cut in a level place at the west end of the coping of the north
wall of the west abutment of the bridge which carries Milburn
e over the East Branch of Rahway River.

JRN. **Eleva., 133.10 ft.**
oss cut in the east end of the coping of the north parapet of the
ridge which carries Milburn Avenue over Rahway River, in Mil-

JRN. **Eleva., 131.55 ft.**
oss cut in the south end (six inches from the outer edge) of the
ill of the Main Street entrance to the banking department of the
ational Bank building.

JRN. **Eleva., 146.24 ft.**
oss cut in the southwest corner of the stone base (near the east
curb) upon which rests the middle of three iron pillars supporting
st end of the bridge which carries the Delaware, Lackawanna
estern Railroad over Main Street.

CLAIR. **265.10 ft.**
oss on the outer corner at the north end of blue sandstone door
entrance to office of the New Jersey Coated Paper Company's
just north of the Erie Railroad station and west of the tracks.

CLAIR. **Eleva., 244.07 ft.**
the outer corner at the southeast end of granite door sill of the
entrance on Bloomfield Avenue to the Delaware, Lackawanna and
rn Railroad station.

CLAIR. **Eleva., 309.79 ft.**
ross on the northwest corner of bridge seat at the west end of
abutment of Erie Railroad bridge over highway just north of
ung Avenue station.

CLAIR. **Eleva., 308.94 ft.**
oss on the level of the top step on the concrete base of iron post
ling at the right hand of stairs leading to street, and near the
face of the Watchung Avenue station on the west side of the
of the Erie Railroad.

CLAIR. **Eleva., 240.54 ft.**
ross cut in the north wall (near the southwest corner of a con-
post, measuring 2.7 feet x 1.2 feet) at the east end of the con-
ridge which carries Bloomfield Avenue over the Delaware, Lacka-
and Western Railroad. The concrete post is at the junction of
rth parapet with the northeast retaining wall.

MONTCLAIR. **Eleva., 250.53 ft.**
A cross cut in the extreme west end of the stone door sill (five inches from a pilaster and near the junction of the west stone balustrade with the building) at the Bloomfield Avenue entrance to the telephone building, which is on the southwest corner of Bloomfield and Gates Avenues.

MONTCLAIR. **Eleva., 296.64 ft.**
A cross cut in the northwest corner of the base of the most easterly of two columns standing in front of the Bank of Montclair building, which is located at 491 Bloomfield Avenue, on the north side of the street and about 180 feet west of north Fullerton Avenue. The column, on the base of which the cross is cut, stands between two windows.

MONTCLAIR. **Eleva., 298.19 ft.**
A cross cut in the east end of the base of a pilaster (4.3 feet from doorway and 1.5 feet above the sidewalk) on the east or left of Bloomfield Avenue entrance to the Young Men's Christian Association building.

MONTCLAIR. **Eleva., 333.01 ft.**
A cross cut in the south end of the water table (3.25 feet north of pilaster and two feet above the ground) on the west or Bell Street side of the Public Service car barns, which stand at the northeast corner of Bloomfield Avenue and Bell Street.

MONTCLAIR HEIGHTS. **Eleva., 400.96 ft.**
A cross on the outer corner at the south end of blue sandstone window sill of the most southerly window on the west face of the boiler house of the State Normal School east of the tracks about 400 yards northeast of the Erie Railroad station.

MONTCLAIR HEIGHTS. **Eleva., 375.78 ft.**
A cross on the cement platform at the center of the north face of the Erie Railroad station on the east side of the tracks.

NEWARK. **Eleva., 15.84 ft.**
A cross cut in the fourth step from the bottom (or the eleventh step from the top) on the south end of the west abutment of the bridge which carries the Lehigh Valley Railroad over Frelinghuysen Avenue.

NEWARK. **Eleva., 12.65 ft.**
A cross cut in the east end of the door sill of the Fenwick Avenue entrance to Engine House No. 19 of the Newark Fire Department, which stands on the northeast corner of Frelinghuysen and Fenwick Avenues.

NEWARK. **Eleva., 24.62 ft.**
A cross cut in the south end of the door sill of the front entrance to the German Methodist Church, at the northeast corner of Walnut and

NEWARK. **Eleva., 68.07 ft.**

A cross cut in the northeast corner of the square marble base of the most northerly of two columns at the north, or left side, of the High Street entrance to the Essex County Courthouse.

NEWARK. **Eleva., 109.92 ft.**

A cross cut in a brownstone base at the foot of the north end of the east truss of the bridge which carries Summit Street over the Morris Canal, at the upper end of the inclined plane.

NEWARK. **Eleva., 119.10 ft.**

A cross cut in the northeast corner of the stone on which the east end of the north truss rests, in the end of the east abutment of the bridge which carries Sussex Avenue over the Morris Canal.

NEWARK. **Eleva., 132.93 ft.**

A cross cut in the south end of the brownstone door sill of the Jay street entrance to the First Infantry Armory, which stands on the south side of Central Avenue between Jay and Hudson Streets. This cross is two and one-half inches from the south wall of the entrance, five inches from edge of sill and eight inches from door jamb.

NEWARK. **Eleva., 120.11 ft.**

A cross cut in the southeast corner of the base of the column against the south wall of the building (four feet back from the corner column) of Engine House No. 15, of the Newark Fire Department, which stands on the north side of Park Avenue, between Sixth and Seventh Streets. The cross is on the northeast column of three, at the entrance to the building.

NEWARK. **Eleva., 117.61 ft.**

This bench mark is the pointed top of a concrete post in the middle of the south parapet of the concrete bridge which carries Bloomfield Avenue over a driveway and stream in Branch Brook Park.

NEWARK. **Eleva., 117.58 ft.**

This bench mark is the pointed top of a concrete post in the middle of the north parapet of the concrete bridge carrying Bloomfield avenue over a driveway and stream in Branch Brook Park.

NEWARK. **Eleva., 120.13 ft.**

A cross cut in the north end of the east abutment (near the east end of the north truss) of the bridge which carries the Orange Branch of the Erie Railroad over the Morris Canal at Forest Hill. The cross is 2.83 feet from the end of truss, three inches from edge and 5.42 feet from the northwest corner of the abutment.

NEWARK. **Eleva., 103.52 ft.**

A cross cut in the north end of the door sill of the most southerly entrance (near circular tower) to Tiffany and Company's factory opposite Forest Hill Station of the Greenwood Lake Branch of the Erie Railroad.

NEWARK. **Eleva., 187.52 ft.**

A cross cut in the north end of the stone door sill of the most southerly Seventh Street entrance of Fire House No. 11 of the Newark Fire Department, which stands on the corner of Central Avenue and Seventh Street.

ORANGE. **Eleva., 195.68 ft.**

This bench mark is the extreme northeast corner of the base of the Soldiers' and Sailors' Monument, standing at the junction of Main and South Main Streets, at the intersection of Prince Street.

ORANGE. **Eleva., 191.04 ft.**
A cross cut in the west end of the door sill of the Main Street entrance to the Young Men's Christian Association building, which stands on the north side of Main Street, east of Park Street. The entrance is at the west end of the building.

ORANGE. **Eleva., 184.64 ft.**
A cross cut in the south end of the sill, on Center Street side, of the corner window, formerly an entrance to the Public Service building, which stands on the southeast corner of Main and Center Streets.

ORANGE. **Eleva., 190.74 ft.**
A cross cut in the southeast corner (0.35 foot from wall, 0.55 foot from end and 3.35 feet from a stone lamp post) of the stone platform at the left of the entrance of the Orange National Bank, which is located one door east of the southwest corner of Main and Cone Streets.

ORANGE. **Eleva., 196.42 ft.**
A cross cut on the west end of the door sill of the main, or middle, entrance (directly under the steeple) of the First Presbyterian Church, which stands on the northwest corner of Main and Day Streets.

ORANGE. **Eleva., 219.84 ft.**
This bench mark is a point on the extreme northwest corner of the base of the monument to the "Dispatch Rider of the American Revolution." This monument stands on the northeast corner of the cemetery, at the southwest corner of Main and Scotland Streets.

ORANGE. **Eleva., 18.27 ft.**
A cross cut in the south end of the door sill of the left entrance to the waiting rooms of the Highland Avenue Station of the Delaware, Lackawanna and Western Railroad.

OVERBROOK. **Eleva., 376.12 ft.**
A cross on the outer corner at the easterly end of bluestone door sill of entrance on the northeast face of workshop or employment building near the railroad and crossing at the Essex County Hospital.

OVERBROOK. **Eleva., 369.17 ft.**
A cross near the outer corner of bridge seat at the westerly end of southerly concrete abutment of Erie Railroad bridge over highway 250 yards southwest of the station at the Essex County Hospital.

OVERBROOK. **Eleva., 359.28 ft.**

SOUTH ORANGE. Eleva., 189.70 ft.

A cross cut in the extreme west end of a stone sill (at a point where it projects from the surface of the wall) of the most westerly window on the north side of the first ell or wing, north from First Street, of the Columbia School building, which stands on the west side of and facing Academy Street, between Irvington Avenue and First Street. There are three wings running back from the main building with two courts. The window sill on which the bench mark was left is the rear of the school building on the court side of the first wing north of First Street.

SOUTH ORANGE. Eleva., 154.82 ft.

A cross cut in the concrete foundation, on the Vose Avenue side, between the corner show window and a column supporting the southeast corner of the Decker Building, which stands on the northwest corner of South Orange and Vose Avenues.

SOUTH ORANGE. Eleva., 137.91 ft.

A cross cut in a shelf (7.5 feet above the river and 1.3 feet below the footpath of the bridge) upon which rests the east end of I-beam, on the north end of the east abutment of the bridge which carries South Orange Avenue over the East Branch of Rahway River. There is also another cross cut in the west end of the north wing wall of the east abutment, 1.25 feet higher. This cross is directly above the bench mark, and must not be confused with it.

UPPER MONTCLAIR. Eleva., 362.26 ft.

A cross on the outer corner at the north end of brown sandstone door sill of the most southerly entrance on the east face of the Mountain Avenue station of the Erie Railroad. The building is west of the tracks.

UPPER MONTCLAIR. Eleva., 351.51 ft.

A cross nine feet from the east end and 0.6 feet below the top, on a ledge of stone on the north face of the south parapet of highway culvert west of the tracks just north of the Erie Railroad station.

UPPER MONTCLAIR. Eleva., 346.18 ft.

A cross on the northwest corner at the north end of blue sandstone coping of the wall supporting the most westerly set of wooden columns of driveway porch on the west side of the Erie Railroad station.

UPPER MONTCLAIR. Eleva., 341.03 ft.

A cross on the outer corner at the south end of door sill of single and center entrance to the Fire House, a stone and brick structure on the west side of Valley Road about 100 yards south of Bellevue Avenue.

VERONA. Eleva., 457.78 ft.

A cross 0.6 feet above the rail on a ledge of stone 17 feet from the east end and on the north face of south abutment of Bloomfield Avenue bridge over the Erie Railroad three-tenths of a mile westerly from the station.

VERONA. Eleva., 424.80 ft.

A cross five feet from the northeast corner of structure and 1.8 feet above the sidewalk on the outer corner at the northeast end of the most easterly window sill on the north face of the school building of the "Boys City Home" of Newark one-half mile northeast of the Erie Railroad station and on the southerly side of the track. The building is the one nearest Fairview Avenue.

WYOMING. **Eleva., 100.44 ft.**

A cross cut in the coping, five feet from the east end of the north parapet, of an arch bridge which carries a road leading from Milburn Avenue to Headleytown over East Branch of Rahway River. This road joins Milburn Avenue 200 feet east of the junction of Ridgewood Road and Milburn Avenue. The bridge is 350 feet southeast from Milburn Avenue.

SECONDARY BENCH MARKS.[1]

BEAUFORT (STATION). **193.7 ft.**

Easternmost joint of north rail at Passaic River bridge about one quarter mile west of station.

BEAUFORT (STATION). **208.3 ft.**

North rail of crossing at the station.

CALDWELL. **413.6 ft.**

North rail of Erie Railroad crossing 0.3 mile west of station.

CALDWELL. **432.9 ft.**

Rail at Erie Railroad station.

CEDAR GROVE. **306.5 ft.**

Rail at station.

ESSEX FELLS. **359.4 ft.**

Southerly rail of Erie Railroad crossing at the station.

MONTCLAIR. **265.1 ft.**

West rail of crossing just north of Erie Railroad station.

MONTCLAIR HEIGHTS. **377.0 ft.**

West rail of southbound track at Erie railroad station.

ROSELAND. **288.5 ft.**

North rail of M. and E. Railroad crossing.

UPPER MONTCLAIR. **342.1 ft.**

West rail of southbound track of Erie Railroad at crossing south of the station.

VERONA. **459.2 ft.**

Rail at station.

GLOUCESTER COUNTY.[2]

BRIDGEPORT. **Eleva., 10.40 ft.**
Copper bolt in monument at the southwest corner of the railroad station.

BRIDGEPORT. **Eleva., 9.12 ft.**
A cross on the northwest corner of the northeast concrete pier supporting steel frame of high water tank of the Bridgeport water works opposite the railroad station.

BRIDGEPORT. **Eleva., 8.24 ft.**
A cross on the outer corner of bridge seat at the south end of west concrete abutment of railroad bridge over Raccoon Creek west of the station.

CENTER SQUARE. **Eleva., 7.08 ft.**
A cross on the northwest corner of concrete base of signal on the north side of the track 0.65 mile southwest of the railroad station or 150 yards northeast of the bridge over Oldman Creek.

CENTER SQUARE. **Eleva., 21.33 ft.**
A cross on the high point of quartz boulder in front of store and post office on the southwest corner of the crossroads in the village.

CENTER SQUARE. **Eleva., 23.80 ft.**
A cross on the outer corner at the west end of door sill of main entrance to Union M. E. Church, a red-brick structure southwest of the crossroads in the village.

CLARKSBORO. **Eleva., 67.28 ft.**
A cross on the outer corner at the east end of cement window sill of the most easterly window on the south face of Fire House No. 1, a cement block structure between the village and the railroad station.

CLARKSBORO. **Eleva., 64.53 ft.**
Top edge of date stone (1880) set in the foundation at the southwest corner of Zion Church, a frame structure between the village and the railroad station.

CLARKSBORO. **Eleva., 54.90 ft.**
Copper bolt in monument at the northeast corner of the railroad station.

CLAYTON. **Eleva., 130.49 ft.**
A cross on the outer corner at the east end of door sill of entrance on the north face of the high school on the easterly side of the railroad, north of the station.

CLAYTON. **Eleva., 125.36 ft.**
Copper bolt set in the south end of door sill of the most southerly entrance on the west face of the West Jersey and Seashore Railroad station.

CLAYTON. **Eleva., 132.84 ft.**
A cross on the south end of marble window sill of the most southerly window on the west face of Fire House, a brick structure two blocks east of the railroad station.

CLAYTON. **Eleva., 136.10 ft.**
A cross on the outer corner at the south end of sandstone door sill of entrance to the Clayton National Bank on the southeast corner of the crossroads, three blocks east of the railroad station. The mark is on the raised portion of the sill.

DOWNER **Eleva., 150.54 ft.**
A cross on the outer corner at the north end of large brownstone door sill of main entrance to the M. E. Church, a stone building 300 yards north of the railroad station.

DOWNER. **Eleva., 149.48 ft.**
Bottom edge of marble corner stone set in the foundation at the northwest corner of the M. E. Church, 300 yards north of the railroad station.

FRANKLINVILLE. **Eleva., 107.72 ft.**
Copper bolt in monument at the northwest corner of the railroad station platform.

FRANKLINVILLE. **Eleva., 108.90 ft.**
A cross on the southeast corner of concrete wall around pump and well at the south face of the railroad station.

FRANKLINVILLE. **Eleva., 106.11 ft.**
A cross on the inner corner, next to the building, at the south end of cement step at entrance on the west face of the hotel east of the station.

FRANKLINVILLE. **Eleva., 97.59 ft.**
A cross on the outer corner at the east end of north concrete parapet of slab bridge over Little Ease River, one-quarter mile southeast of the railroad station. The mark is at the end of the iron railing and the bridge is in the road leading direct to Malaga.

FRANKLINVILLE. **Eleva., 100.02 ft.**
A cross on concrete foundation at the southwest corner of brick school house, one-quarter mile east of the railroad station.

GIBBSTOWN. **Eleva., 17.78 ft.**
A cross on the outer corner at the east end of door sill of entrance on the north face of public school building, south of the railroad track on the main highway between Green's Station and Gibbstown.

GIBBSTOWN. **Eleva., 12.37 ft.**
Copper bolt in monument at the southeast corner of freight house of the Pennsylvania Railroad.

GIBBSTOWN. **Eleva., 16.13 ft.**
A cross on the south end of basement window sill under the tower and on the west face of the Gibbstown M. E. Church, a stone structure at the crossroads south of the railroad station.

GLASSBORO. **Eleva., 151.30 ft.**
A cross on the outer corner at the southerly end of door sill of corner entrance to the First National Bank on the corner of Main and High Streets.

GLASSBORO. **Eleva., 151.76 ft.**

HARDING. Eleva., 141.65 ft.

Copper bolt in concrete monument at the southwest corner of the railroad station.

HARRISONVILLE. Eleva., 54.94 ft.

Copper bolt in monument at the north face of the railroad station.

IONA. Eleva., 92.30 ft.

A cross on the outer corner of bedplate stone on which rests the south end of the west girder of railroad bridge over Scotland Run about ½ mile south of the station.

MALAGA. Eleva., 106.74 ft.

A cross on the southwest corner of the most southerly of two concrete piers of signal frame on the west side of the tracks just north of the railroad station.

MALAGA. Eleva., 107.33 ft.

A cross on the southwest corner of concrete wall around well and pump at the north end of the station.

MICKLETON. Eleva., 55.37 ft.

A cross on the southeast corner of concrete wall encasing well at the southeast corner of the railroad station.

MICKLETON. Eleva., 69.34 ft.

A cross on the flagstone curbing around porch floor at the base of the left-hand iron post of porch as you enter the most westerly door on the south face of the Friends Meeting House at the crossroads in the village.

MOUNT ROYAL. Eleva., 36.47 ft.

On the outer corner, 0.65 feet above the sidewalk, at the westerly end of cement step of entrance to post office and store on the southerly side of the main street at the junction with the road to the railroad station in the village.

MULLICA HILL. Eleva., 52.35 ft.

A cross 3.3 feet south of and 1.33 feet below the rail of track on the east concrete abutment of Reading Railroad bridge over Raccoon Creek just east of the station.

MULLICA HILL. Eleva., 52.48 ft.

A cross on the cement cap at the north end of east parapet of concrete highway bridge over Raccoon Creek about 100 feet north of the railroad at the station.

MULLICA HILL. Eleva., 96.31 ft.

Top of iron mile post reading "7M. to W." at the right of the entrance to grounds of the Friends Meeting House at the junction of the main street and the Woodstown road. The post is immediately at the iron fence.

MULLICA HILL. Eleva., 105.49 ft.

A cross on the outer corner at the north end of cement door sill of entrance on the east face of the public school, a brick and stone structure on the Woodstown road near the Friends Meeting House.

MULLICA HILL. Eleva., 58.15 ft.

On the outer corner at the north end of door sill of main entrance to the Farmers National Bank, about 300 yards north of the railroad station.

MULLICA HILL. Eleva., 69.82 ft.

On the outer corner at the north end of cement door sill of main entrance to the Episcopal Church on the east side of the main street north of the railroad station.

MULLICA HILL. **Eleva., 34.33 ft.**
A cross on small ledge of stone 0.54 feet below the top and at the northeast corner of north parapet of highway culvert over a branch of Raccoon Creek, 1.8 miles west of Mullica Hill on the Swedesboro road which runs north of and parallel to Raccoon Creek.

NEWFIELD. **Eleva., 93.98 ft.**
A cross on the center of the west parapet of concrete highway bridge on the west side of the railroad about 0.7 mile north of the station.

NEWFIELD. **Eleva., 115.49 ft.**
A cross on the southeast corner of the most southerly of two concrete piers supporting signal frame on the west side of the railroad about 250 yards north of the station.

NEWFIELD. **Eleva., 115.55 ft.**
A cross on the outer corner of the extreme north end of granite door sill of entrance on the west face of the Edgarton school, a yellow brick structure about 0.35 mile east of the railroad station.

NEWFIELD. **Eleva., 116.45 ft.**
A cross on the outer corner at the north end of door sill of entrance on the west face of the compressor house of the railroad signal system. The structure is on the south side of the crossing just north of the station.

NEWFIELD. **Eleva., 115.92 ft.**
A cross on the northwest corner of concrete wall around pump at the north face of the railroad station.

OGDEN STATION. **Eleva., 13.24 ft.**
A cross on the center of east parapet of concrete highway bridge just south of the station.

PAULSBORO. **Eleva., 11.87 ft.**
A cross on the south end of door sill of the most southerly entrance on the west face of public school on the east side of Delaware Avenue at Washington Street.

PAULSBORO. **Eleva., 14.13 ft.**
A cross on the outer corner at the north end of door sill of tower entrance of St. Paul's M. E. Church on the corner of Delaware Avenue and Broad Street.

PAULSBORO. **Eleva., 12.80 ft.**
A cross on the outer corner at the east end of door sill of entrance

PITMAN. **Eleva., 128.06 ft.**
On the southeast corner of base stone of the most southerly of two large columns at the entrance to the Pitman National Bank.

PITMAN. **Eleva., 142.65 ft.**
A cross on the outer corner at the south end of door sill of entrance on the west face of the annex to public school building. The annex is at the north face of the structure at the corner of Holly and Mt. Vernon Avenues.

PITMAN. **Eleva., 142.60 ft.**
Top edge of brown sandstone base at the northwest corner of public school building on the corner of Holly and Mt. Vernon Avenues. The elevation is on the level of the basement window sills.

RADIX. **Eleva., 139.12 ft.**
On the center of cement cap of the east cement block post at steps leading to porch of farmhouse on the south side of the highway 50 yards east of the railroad station.

RICHWOOD. **Eleva., 152.76 ft.**
A cross next to the door jamb on the cement floor at the right side of large double door entrance to a garage on the southeast corner of the crossroads.

SEWELL. **Eleva., 67.56 ft.**
Next to the building on the north end of the top cement step at the corner entrance of a two story frame structure 100 feet easterly from the railroad on the north side of the highway at the station. The point is 0.66 feet below the wooden door sill.

SEWELL. **Eleva., 31.98 ft.**
A cross 6.8 feet below the bridge floor on the northwest corner of flagstone coping at the north end of easterly pier of highway bridge over Chestnut Branch of Mantua Creek about one-quarter mile southwest of the railroad station.

SEWELL. **Eleva., 65.90 ft.**
On the outer corner at the north end of cement door sill of entrance under the porch and on the easterly face of a brick dwelling on the northwest corner of Atlantic Avenue and Cumberland Boulevard on the westerly side of the railroad and about 300 yards north of the station.

SWEDESBORO. **Eleva., 15.42 ft.**
A cross 3.6 feet from the iron railing of sidewalk on the outer corner of cement cap at the north end of westerly abutment of Main Street bridge over Raccoon Creek on the east edge of the town. The mark is above the bridge seat.

SWEDESBORO. **Eleva., 34.92 ft.**
A cross on the outer corner at the easterly end of marble door sill of entrance in the southerly face of the Presbyterian Church on the corner of Main and Church Streets.

SWEDESBORO. **Eleva., 39.66 ft.**
A cross on the outer corner at the northeast end of large door sill of front entrance to the public school, a stone building on Main Street.

SWEDESBORO. **Eleva., 42.47 ft.**
On the outer corner at the extreme northeast end of a large sill of Main Street entrance to the Swedesboro National Bank on the corner of Railroad Avenue.

SWEDESBORO. **Eleva., 40.43 ft.**
This bench mark is a cross cut on the southerly end of marble door sill of front door of brick M. E. Church near the northwest corner of Main Street and Railroad Avenue.

SWEDESBORO. Eleva., 40.12 ft.

On the outer corner of the southwest end of door sill on Main Street entrance to the Swedesboro Trust Company's building on Main Street nearly opposite Railroad Avenue.

THOROFARE. Eleva., 25.25 ft.

A cross on the outer corner at the west end of window sill of small window on the south face and on the left of the main entrance to public school, a stone structure one-quarter mile westerly from the railroad station.

WENONAH. Eleva., 62.62 ft.

A copper bolt in north end of door sill of entrance to waiting room on the west face of the railroad station.

WENONAH. Eleva., 59.39 ft.

Next to the building on the extreme westerly end of cement door sill of corner entrance to the Grosscup building, a one-story structure on the northwest corner of Mantua and West Jersey Avenues west of the tracks at the railroad station.

WENONAH. Eleva., 62.55 ft.

A cross on the outer corner at the north end of sandstone door sill of entrance to waiting room on the east face of the railroad station..

WENONAH. Eleva., 74.43 ft.

A cross on the outer corner at the east end of door sill of the most easterly entrance on the north face of the Presbyterian Church on Main Street, two blocks east of the railroad station.

WENONAH. Eleva. 84.06 ft.

A cross on the outer edge 0.4 feet from the east end of cement sill and top step at entrance to the alcove on the south face of a public school building on the northwest corner of Elm Street and North Clinton Avenue.

WESTVILLE. Eleva. 11.25 ft.

A cross on the outer corner at the southwest end of marble door sill of entrance to waiting room on the east face of the railroad station.

WESTVILLE. Eleva. 16.22 ft.

A cross on marble base stone, 17 feet measured southerly from the northwest corner of a brick structure on the easterly side of Broadway at the head of Pine Street. The building is occupied jointly by the [redacted]

WILLIAMSTOWN. **Eleva., 165.86 ft.**

On the outer corner at the southwest end of cement door sill of rear entrance to Bennett's Department Store, a yellow-brick structure on the westerly side of the main street at the corner, one block southeast of the bank.

WILLIAMSTOWN. **Eleva., 157.84 ft.**

On the outer corner at the extreme northwest end of cement door sill of rear entrance on the easterly face of the First National Bank.

WILLIAMSTOWN. **Eleva., 161.76 ft.**

On the southeast end of stone window sill of the most southerly of four windows on the easterly face of the First National Bank.

WILLIAMSTOWN. **Eleva., 166.89 ft.**

A cross next to the brick work on the west end of sandstone door sill of entrance on the south face of Maple Grove Grammar School near the Church Street railroad station.

WOLFERT STATION. **Eleva., 20.40 ft.**

A cross on the outer corner of stone cap at the northeast end of northwest parapet of railroad culvert about 0.35 mile northeast of the station.

WOODBURY. **Eleva., 37.59 ft.**

This bench mark is a cross cut on the south end of stone door sill of front entrance of G. G. Green's brick laboratory, which faces the railroad just south of West Jersey Railroad depot.

WOODBURY. **Eleva., 62.63 ft.**

This bench mark is a cross cut on southeast corner of the lowest of three marble bases of soldiers' monument in front of court house.

WOODBURY. **Eleva., 65.32 ft.**

A cross on the outer corner at the north end of brown sandstone door sill of front entrance to the court house.

WOODBURY. **Eleva., 61.86 ft.**

A cross on the outer corner at the southerly end of granite door sill of the most northerly entrance on Broad Street to the M. E. Church just south of Cooper Street.

WOODBURY. **Eleva., 57.77 ft.**

A cross on the outer edge near the extreme north end of granite door sill of Broad Street entrance to the First National Bank just south of Cooper Street.

WOODBURY. **Eleva., 58.25 ft.**

A cross on the outer corner at the north end of door sill of Broad Street entrance to the Presbyterian Church corner of West Centre Street. The entrance is back under the porch.

SECONDARY BENCH MARKS[1].

ASBURY STATION. **55.6 ft.**

Southeast rail of crossing.

ASBURY STATION. **47.76 ft.**

A cross on the southwest corner of concrete base of signal on the easterly side of the railroad about 175 yards northeast of the station.

AURA. **144.99 ft.**

A cross cut in the northwest corner of concrete base of signal on the west side of the track just north of the railroad station.

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[1] "Rail at station" refers to rail joint nearest center of station. "Rail at crossing" refers to rail joint if there is one; otherwise to height of rail at center of roadway.

AURA. 145.3
Westerly rail of track of second crossing north of the station.

AURA. 147.12 ft.
On the outer corner at the west end of wooden door sill of front trance to the M. E. Church at the railroad station.

CENTER SQUARE. 5.3 ft.
North rail of crossing at the station.

CLARKSBORO. 54.5 ft.
North rail of crossing at the railroad station.

CLARKSBORO. 65.09 ft.
A cross on the cement sidewalk at the northwest corner of buil used as a general store on the southeast corner of the crossroads, quarter of a mile southerly from the railroad station.

CLAYTON. 126.6 ft.
East rail of north bound track of crossing, 15 yards south of station.

COOPER STATION. 9.8 ft.
South rail of crossing one-quarter mile east of.

COOPER STATION. 18.4 ft.
North rail of crossing.

DOWNER. 145.1 ft.
North rail of main track of crossing at the station.

DOWNER. 147.34 ft.
Bottom edge of base board at the southwest corner of dwelling store, 100 feet north of the railroad on the east side of the highw at the station.

DOWNER. 139.9 ft.
North rail of crossing one mile northwest of station.

FRANKLINVILLE. 107.2 ft.
West rail of south bound track crossing at the station.

FRANKLINVILLE. 111.02 ft.
Bottom edge of corner strip at the northwest corner of Post Off opposite the railroad station.

GIBBSTOWN. 11.6 ft.
North rail of crossing on the west side of the railroad station.

ORO. 143.9 ft.
ιil of crossing 0.8 mile south of South Glassboro station.

ƆRO. 142.9 ft.
ail of diagonal crossing 1.4 miles south of South Glassboro

STATION. 14.5 ft.
ail of crossing.

ɜ. 141.4 ft.
ιil of crossing at the railroad station.

NVILLE. 54.99 ft.
on the northwest corner of concrete base of signal east of and 60 yards north of the railroad station.

NVILLE. 55.7 ft.
ιil of the most southerly of two crossings just north of the tation.

NVILLE. 62.2 ft.
ιil of crossing three-quarters of a mile north of the railroad

105.5 ft.
il of crossing.

93.1 ft.
il of diagonal crossing 200 yards north of the station.

86.6 ft.
il of crossing 200 yards north of the station.

ON. 79.6 ft.
ail of crossing at the station.

ON. 76.04 ft.
on the center of the west concrete parapet of small highway st east of the station and north of the tracks.

106.6 ft.
.il of crossing at the station.

93.8 ft.
.il of crossing one mile north of the station.

111.3 ft.
ιil of southbound track of crossing, 0.5 mile south of the

ON. 55.5 ft.
ly rail of crossing at the station.

ON. 55.18 ft.
concrete foundation at the southeast corner of Haines and oduce building at the railroad station.

ON. 69.53 ft.
end of wooden door sill of the most westerly entrance on face of the Friends' Meeting House.

ROYAL. 53.2 ft.
ail of crossing of the Clarksboro-Mount Royal highway, one-southwest of the station.

ROYAL. 44.38 ft.
southwest end of wooden window sill of the most westerly window on the southerly face of the Baptist Church.

ROYAL. 34.5 ft.
y rail of crossing at the station.

MULLICA HILL. . **51.8 ft.**
South rail of crossing at the station.

MULLICA HILL. **53.11 ft.**
A cross on the concrete foundation at the northeast corner of th railroad station.

MULLICA HILL. **97.29 ft.**
A cross at the base of iron post of porch and near the outer corn at the east end of top step of three porch steps of Town Hall.

NEWFIELD. **101.7 ft.**
West rail of south bound track of crossing 0.9 mile north of the statio

NEWFIELD. **116.4 ft.**
West rail of south bound track of Vineland branch at the crossin just north of the station.

NEWFIELD. **103.0 ft.**
East rail of crossing 0.5 mile south of the station on the Vinela branch.

NORTH WOODBURY. **45.0 ft.**
East rail of crossing at the station.

NORTH WOODBURY. **47.3 ft.**
East rail of diagonal crossing 200 yards north of the railroad statio

OGDEN STATION. **14.5 ft.**
North rail of crossing.

PARADISE. **15.5 ft.**
North rail of crossing at the station.

PARKVILLE STATION. **37.6 ft.**
South rail of crossing.

PAULSBORO. **12.9 ft.**
South rail of crossing just west of the station.

PITMAN. **138.9 ft.**
East rail of south bound track at crossing three-quarters mile sou of the railroad station.

PITMAN. **135.2 ft.**
West rail of crossing just north of the station.

PITMAN. **108.7 ft.**
West rail of diagonal crossing one mile north of the railroad statio

PROSPECT. **4.7 ft.**
South rail of main track of crossing at the station.

RADIX. **140.8 ft.**

ROBANNA. 157.6 ft.
Point of frog of siding at the station.

ROBANNA. 152.5 ft.
South rail of crossing 300 yards west of the station.

RULON. 55.2 ft.
Southeast rail of crossing at the station.

RULON. 51.4 ft.
Westerly rail of crossing, one-half mile northeast of the station.

SEWELL. 65.0 ft.
Westerly rail of crossing at the station.

SHERWIN STATION. 121.9 ft.
West rail of crossing.

SOUTH WESTVILLE. 26.3 ft.
Southeast rail of crossing at the station.

SWEDESBORO. 35.5 ft.
Southeast rail of tracks of the first crossing northeast of the station.

TATEM STATION. 57.5 ft.
South rail of crossing.

THOROFARE. 22.2 ft.
Point of frog 30 yards east of the station.

THOROFARE. 19.8 ft.
South rail of crossing at the station.

THOROFARE. 20.4 ft.
Northeast foundation bolt of gasoline stand on the west side of the highway 30 yards south of the railroad.

TOMLIN STATION. 43.5 ft.
Southeast rail of crossing.

WENONAH. 60.1 ft.
West rail of tracks of crossing at the station.

WESTVILLE. 10.1 ft.
Southeast rail of tracks of crossing just north of the railroad station.

WESTVILLE. 15.4 ft.
East rail of crossing, three-quarters mile northeast of the railroad station. This is the main Woodbury-Gloucester highway.

WILLIAMSTOWN. 157.4 ft.
North rail of crossing, 50 yards northeast of the railroad station.

WILLIAMSTOWN. 156.2 ft.
Northeast rail of crossing at Church Street station.

WILLIAMSTOWN. 159.9 ft.
Northeast rail of crossing about 350 yards northwest of the Church Street station. This is the main Sicklertown-Franklinville highway.

WOLFERT STATION. 49.7 ft.
Northwest rail of main track at crossing.

WOODBURY. 42.6 ft.
South rail of crossing just east of West End station of the Pennsgrove branch of the Pennsylvania Railroad.

WOODBURY. 36.7 ft.
Westerly rail of tracks of crossing at the station.

WOODBURY HEIGHTS. 52.7 ft.
West rail of tracks of crossing at the station.

WOODBURY HEIGHTS. 54.56 ft.
A cross on the cement platform at the northwest corner of the railroad station.

HUDSON COUNTY.[1]

BAYONNE. **Eleva., 33.92 ft.**

A cross on the outer corner at the westerly end of blue sandstone wi dow sill on the East 49th Street face and at the southwest corner Public School No. 3, on the corner of East 49th Street and Broadwa

BAYONNE. **Eleva., 32.02 ft.**

A point 2.14 feet above the door sill on the white sandstone copi at the left side as you enter the most westerly door from East 3 Street of the Mechanics Trust Company's building on the corner East 33d Street and Broadway.

BAYONNE. **Eleva., 48.20 ft.**

On the outer corner of granite sill of basement window on the nort erly side of Avenue C entrance to the Bayonne Public Library at We 31st Street.

BAYONNE. **Eleva., 42.26 ft.**

A cross on the outer corner at the easterly end of window sill basement window on the northerly face and at the northeast corner Public School No. 8, a red brick structure on Avenue C at 28th Stre

BAYONNE. **Eleva., 40.81 ft.**

A cross on the outer corner 1.8 feet from the door at the norther end of large stone door sill of the Avenue C entrance to the Municip Building at 26th Street.

BAYONNE. **Eleva., 21.10 ft.**

Copper bolt 1.73 feet above the bridge seat and three feet from t girder on the westerly end of south concrete abutment of bridge carryi the New Jersey Central Railroad over the first street southerly fro the East 22d Street station.

BAYONNE. **Eleva., 15.57 ft.**

On the outer corner 3.7 feet from the outer set of doors at the nor erly end of large granite sill of the Broadway entrance to building the Bayonne Trust Company, a stone structure on the westerly side Broadway at 9th Street.

BAYONNE. **Eleva., 26.14 ft.**

A cross on the outer corner at the southerly end of door sill of e trance to baggage room on the west face of the station of the Ne

RISON. **Eleva., 32.51 ft.**
cross cut near the southeast corner of the base of the column ing at the right, or east side of the front entrance to the West n Trust Company's building, on the north side of Harrison ie, just west of Kearny Avenue.

IISON. **Eleva., 56.29 ft.**
ross cut in the east end of the south abutment, on a shelf (2.9 elow the footpath) upon which rests the south end of the east f the bridge which carries Kearny Avenue over the Erie Railroad.

KEN. **Eleva., 5.85 ft.**
ss on the outer corner at the south end of door sill of the Park entrance to Public School No. 7 on Newark Street.

:EN. **Eleva., 15.19 ft.**
ss on the outer corner at the easterly end of door sill of the esterly basement entrance on Newark Street to the City Hall mfield Street.

EN. **Eleva., 14.68 ft.**
ss next to door jamb at the northerly end of door sill of River ntrance to post office at Newark Street. The sill is back under ve.

EN. **Eleva., 45.73 ft.**
ss on the outer corner at the southerly end of brown sandstone l of River Street entrance to the main Institute building at Institute of Technology. The structure faces the park.

EN. **Eleva., 47.49 ft.**
ss on the outer corner at the northerly end of door sill of the rtherly entrance on River Street to the United States Naval ; on the grounds of Stevens Institute of Technology.

EN. **Eleva., 6.18 ft.**
ss on the outer corner at the westerly end of door sill of entrance northerly face and near the northeast corner of Fire House ls Truck No. 2 on Newark Street, near Henderson.

' CITY. **Eleva., 94.93 ft.**
ss cut in the south corner of the upper large square stone step main entrance (on Summit Avenue) of the Westminster Pres-Church, at the east corner of Summit and Magnolia Avenues.

' CITY. **Eleva., 99.65 ft.**
s cut in the east end of the sand stone sill of the most westerly loors in the Newark Avenue front of the Hudson County Jail, Oakland Avenue.

CITY. **Eleva., 101.22 ft.**
s cut in the south end of the door sill (10 inches from the door ; inches from the south side of the entrance and 1.3 feet from edge of the sill) of the most easterly of three entrances from Avenue to the Hudson County Courthouse, which stands on the ner of Newark and Pavonia Avenues.

CITY. **Eleva., 26.25 ft.**
; cut in the north end of the east abutment, at the foot of the of the north truss of a small viaduct which carries a 30 inch in over the tracks of the West Shore or Junction Railroad, just the bridge carrying Newark Avenue over the same railroad.

JERSEY CITY. **Eleva., 18.65 ft**

A cross cut in the north side of the stone base of the fifth, or li pilaster from Montgomery Street, on the Washington Street side of Union Trust Company's building, which stands on the southwest cor of Montgomery and Washington Streets.

JERSEY CITY. **Eleva., 6.99 ft**

A cross cut in the top of the south wall of Morris Canal lock No. The cross is 14.1 feet from the head, or drop gate, 20.4 feet from stone steps leading to the street and 0.12 foot from the edge of the w This lock is at Washington Street.

JERSEY CITY. **Eleva., 8.90 ft.**

A cross on the northeast corner of stone forming the bottom st of a series of steps at the north end of westerly abutment of Pen sylvania Railroad bridge over Washington Street.

JERSEY CITY. **Eleva., 19.40 ft.**

On the outer corner at the south end of granite door sill of th Washington Street entrance to basement of the Hudson County Nation Bank at York Street. The entrance is the first from York Street an the sill is below the sidewalk.

JERSEY CITY. **Eleva., 23.06 ft.**

A cross on the outer corner at the east end of granite door sill o the York Street entrance to the post office at the southwest corner o building.

JERSEY CITY. **Eleva., 21.39 ft.**

A cross on the inner corner, next to face of building, at the wes end of large granite door step and sill of the most easterly entranc on Sussex Street to School No. 16 at Washington Street.

JERSEY CITY. **Eleva., 10.03 ft.**

A cross on the northwest corner of fourth stone step from the to at the north end of easterly abutment of New Jersey Central Railroa bridge over the Morris Canal, about one-half mile northeast of Va Nostrand Avenue.

JERSEY CITY. **Eleva., 149.73 ft.**

A cross on the outer corner at the northerly end of granite sill o basement window on the Summit Avenue face of the Second Dutc Reformed Church on the easterly side of Summit Avenue betwee

EY CITY (LAFAYETTE). **Eleva., 12.86 ft.**
ross on the outer corner at the east end of door sill of center
ce on Communipaw Avenue to factory of the American Musical
y Company, a red brick structure on the southerly side of Com-
aw Avenue about 100 feet east of the Morris Canal.

NY. **Eleva., 121.90 ft.**
ross cut in the first of two steps (0.7 foot from southwest corner
, 15.5 feet from junction of the west wing wall with the northwest
of the bridge, and 3.4 feet below the roadbed) in the west end
north abutment of the bridge which carries Kearny Avenue over
eenwood Lake Branch of the Erie Railroad, about 1,500 feet west
Arlington Station.

NY. **Eleva., 111.11 ft.**
oss cut in the southeast corner of the large stone landing, five
lown from the door, of the entrance to the Town Hall. This cross
the corner formed by the junction of the south stone balustrade
he building. The Town Hall stands on the east side of Kearny
e nearly opposite Grove Street.

DURHAM. **Eleva., 7.91 ft.**
ross cut in the lowest of a series of steps (near the edge and
ıp to the bottom of the next step above) at the west end of the
abutment of the bridge which carries the Hackensack Turnpike
he West Shore Railroad at the station.

DURHAM. **Eleva., 33.21 ft.**
ross on the outer corner at the southerly end of blue sandstone
ill of entrance on the easterly face of Public School No. 3, of
Bergen Township on North Street, northeast of the West Shore
ad station.

I, TOWN OF. **Eleva., 191.74 ft.**
oss near the outer edge at the westerly end of granite door sill
n entrance to building of the Trust Company of New Jersey—Town
on Branch, situated on the corner of Hackensack Plank Road and
ı Line Avenue.

I, TOWN OF. **Eleva., 170.84 ft.**
oss on the outer corner at the easterly end of door sill of corner
ce on Main Street to Necker Building on the southwest corner
in street and Bergen Line Avenue.

I, TOWN OF. **Eleva., 167.03 ft.**
ross on the outer corner at the southerly end of blue sandstone
ill of the main entrance to the Town Hall on Hudson Boulevard
in Street.

I, TOWN OF. **Eleva., 181.50 ft.**
oss on the outer corner at the westerly end of basement window
the northwest corner of the building and on the Fourth Street
f Public School No. 2, located at Fourth Street and Bergen Line
e. The window is in that portion of the structure nearest Fourth

I, TOWN OF **Eleva., 179.17 ft.**
oss on the outer corner at the extreme southerly end of granite
ill of Bergen Line Avenue entrance to the Weehawken Trust
ny's building at Fourth Street.

HOBOKEN. **Eleva., 174.20 ft.**
oss on the outer corner at the southerly end of blue sandstone
ill of Summit Avenue entrance to the Highland Trust Company's
g on the corner of Summit and DeMott Avenues.

WEST HOBOKEN. Eleva., 174.84 ft.
A cross on the outer corner at the easterly end of granite door sill of the main entrance to National Bank of North Hudson at the triangular corner formed by the intersection of Paterson Plank Road, DeMott Street and Summitt Avenue.

WEST HOBOKEN. Eleva., 183.64 ft.
A cross on the outer corner at the southerly end of door sill of single door entrance on Hudson Boulevard, and near the southwest corner of the building to garage of Decker & Keynton—a red brick structure on the easterly side of Hudson Boulevard at No. 3828.

WEST HOBOKEN. Eleva., 186.20 ft.
A cross on the outer corner of door sill of the Elm Street double door entrance to Public School building on the corner of Elm Street and Summit Avenue.

WEST HOBOKEN. Eleva., 190.58 ft.
A cross on the outer corner at the westerly end of window sill on the right hand as you enter the office of the Public Service car barns on the corner of Clinton Avenue and Angelic Street. The tower is at this corner of the structure.

WEST HOBOKEN. Eleva., 193.61 ft.
A cross on the outer corner at the easterly end of basement window sill on the north face and near the northeast corner of Public School No. 5 at Jane Street and Clinton Avenue.

WEST HOBOKEN. Eleva., 192.11 ft.
A cross on the outer corner at the easterly end of granite door sill of main entrance to building of the Hudson Trust Company on the corner of Spring Street and Hackensack Plank Road. The cross is on the raised portion of the sill adjacent to the brick work.

WEST NEW YORK. Eleva., 184.41 ft.
A cross 4.6 feet from the southwest corner of building on the west end of blue sandstone window sill of basement window on the Sixteenth Street face of the Municipal Building one block easterly from Bergen Line Avenue at the corner of Harrison Place.

WEST NEW YORK. Eleva., 217.00 ft.
On the extreme southerly end of blue sandstone door sill of the Bergen Line Avenue entrance to the red brick church on the corner of Twenty-

ANNANDALE. **Eleva., 355.049 ft.**

The bottom surface of a square cavity cut on a projecting stone, about the center of the north abutment of an overhead highway bridge, over the Central Railroad, about one mile east of the station. The mark is a little below the level of the railroad track in hard blue limestone. This is a bench mark of the U. S. Coast and Geodetic Survey.

ANNANDALE. **Eleva., 345.66 ft.**

A cross on the east end of stone door sill at the west entrance of the Central Railroad station, on the side toward the tracks.

ANNANDALE. **Eleva., 342.99 ft.**

A cross 3 inches diagonally from the southwest corner of a cement block, forming the top of a series of steps at the south end of the west abutment of a bridge carrying the Central Railroad over a highway about 800 feet west of the station.

ANNANDALE. **Eleva., 350.54 ft.**

A cross about two and one-half feet above the track on the outer corner at the southerly end of northeast stone abutment of frame bridge over the railroad about three-quarters mile northerly from the station.

ANNANDALE. **Eleva., 320.46 ft.**

Next to the brick work on the brown sandstone water table at the northwest corner of brick dwelling on the east side of the High Bridge road about 130 yards south of Center Street.

ANNANDALE. **Eleva., 302.70 ft.**

A cross just below the wooden door sill on the inner corner at the north end of top step, or landing, of three flagstone steps at entrance to the Reformed Church at the intersection of the Clinton and High Bridge roads.

ANNANDALE. **Eleva., 302.70 ft.**

On the marble corner stone set in the foundation at the southwest corner of the Reformed Church.

ANNANDALE. **Eleva., 220.88 ft.**

A cross directly above the west edge of opening for stream on the outer corner at the west end of the north concrete parapet of highway bridge about three-quarters mile from Annandale on the road to Clinton.

BLOOMSBURY. **Eleva., 326.180 ft.**

The bottom of a square cavity cut in the top stone at the northwest corner of a railroad bridge over the wagon road, one-fourth mile west of the Central Railroad station. This is a U. S. Coast and Geodetic Survey bench mark. It is marked thus: B [‾] M
1881.

BYRAM. **Eleva., 100.51 ft.**

On the north end of west concrete parapet of arch culvert under the railroad about one mile north of the station. This is a railroad bench mark and is number 16.

BYRAM. **Eleva., 101.45 ft.**

A cross on the northeast corner of a concrete pier supporting a wooden bridge over the Pennsylvania Railroad, about 800 feet north of the station. The cross is about two feet above the level of the rails, and eight feet west of the west rail.

BYRAM. **Eleva., 97.77 ft.**

A copper bolt on the north end of the wall of a railroad culvert, about 300 feet south of Byram station, on the west side of the track.

BYRAM. **Eleva., 97.76 ft.**

A cross on the northeast corner at the north end of concrete parapet of railroad culvert about 100 yards south of the station.

BYRAM. **Eleva., 100.68 ft.**
A cross on the northwest corner of a concrete block on which re the northeast end of the north truss, at the northeast abutment of t bridge over the Delaware.

BYRAM. **Eleva., 94.31 ft.**
A cross on the inner corner of the fourth stone step from the top the northerly end of the easterly abutment of stone arch bridge under railroad about three-quarters mile southeast of the station.

CALIFON. **Eleva., 479.15 ft.**
A cross on the center of concrete slab at the southerly end of sm culvert under the Central Railroad about 450 yards westerly from t station.

CALIFON. **Eleva., 483.98 ft.**
A cross on the outer corner at the easterly end of door sill of entra on the southerly face of the Central Railroad station, a stone struct on the north side of the tracks.

CALIFON. **Eleva., 469.78 ft.**
A cross on the outer corner, six inches below the bridge floor at t west end of southerly abutment of highway bridge over South Bran of Raritan River.

CALIFON. **Eleva., 480.84 ft.**
A cross immediately below the iron railing and directly over t pier on the southerly cement walk of highway bridge about 300 yar north of the railroad station. The bridge is on the northerly side of t railroad and the highway parallels the tracks.

CLINTON. **Eleva., 202.07 ft.**
A cross on the northeast corner of the south wing wall, on the blu stone cap, of the highway bridge over south Branch of Raritan Riv near the intersection of Lee and Center Streets.

CLINTON. **Eleva., 208.86 ft.**
A cross on the westerly end of bluestone door sill of main entrance the Union Hotel on the corner of Lee and Center Streets.

CLINTON. **Eleva., 195.95 ft.**
A cross on the outer edge, at left of doorway, of the door sill at t entrance to the Clinton National Bank.

CLINTON. **Eleva., 194.37 ft.**
A cross on the extreme north point of the center pier of the Ma

TTSTOWN. **Eleva., 320.72 ft.**
ss on the outer corner at the west end of the south abutment ooden bridge, over the south branch of Nishisakawick Brook, 00 feet east of the general store at the corner of the crossroads.

TTSTOWN. **Eleva., 337.53 ft.**
e bottom edge and corner of brownstone tablet, at the northeast of the Methodist Episcopal Church.

TSTOWN. **Eleva., 405.78 ft.**
ss about one foot below the bridge floor on the outer corner at t end of the south abutment of highway bridge over a brook .2 miles northeast of Everittstown. The bridge is about one rtherly from Palmyra, on the road leading to Jutland and just its intersection with the road leading easterly to Pittstown.

TSTOWN. **Eleva., 397.08 ft.**
ss on a ledge of stone in the center and on the north face of arapet of stone arch highway bridge over a brook about one rtheast of Everittstown. The bridge is on the Pittstown road .7 mile northerly from Palmyra and the cross is at the lower a marble slab set in the wall and reading "Freeholder—Philip Superintendent A. Shaw & C."

TSTOWN. **Eleva., 330.12 ft.**
ss on the outer corner at the west end of bottom step of several eps leading into a yard on the north side of the Pittstown road 0 yards east of the general store at the crossroads.

TSTOWN. **Eleva., 321.70 ft.**
ss on the outer corner at the northeast end of northerly abut- highway bridge over the north branch of Nishisakawick Creek s northwest of the general store at the crossroads.

TSTOWN. **Eleva., 333.23 ft.**
ss next to the building at the right of the doorway on the bottom e step at main entrance to the M. E. Church at intersection of Pleasant and Frenchtown roads.

NGTON. **Eleva., 187.45 ft.**
bench mark is a cross on the south end of the door sill at the trance of the courthouse.

NGTON. **Eleva., 186.29 ft.**
bench mark is on top of the brass head of the southern "true n" post in front of the courthouse.

NGTON. **Eleva. 171.26 ft.**
bench mark is a cross cut on the west end of the door sill, at thwest corner of the stone Presbyterian Church, at the forks of et.

HTOWN. **Eleva., 276.64 ft.**
ss in the cover of the cement wall at the entrance, directly he hinges of the door at the top edge of the reservoir of the own Water Works, one-quarter mile north of the village, on the Everittstown.

HTOWN. **Eleva., 133.29 ft.**
ss on the northeast corner of a large block in front of the l Hotel on Milford road, opposite Kingwood Avenue. The stone and one-half feet from the porch of the hotel.

HTOWN. **Eleva., 129.06 ft.**
ss on the course of stones forming the seat of the truss, about es below the level of the floor, and at the bridge end of a long all running northeast, at the northeast corner of the southeast nt of a bridge over the brook on Kingwood road, 100 feet from road, and opposite National Hotel.

FRENCHTOWN. **Eleva., 129.90**
On the outer corner at the east end of a brownstone door sill, at right side of the entrance to the bank building on Bridge Street. point is immediately below the right brick door jamb.

FRENCHTOWN. **Eleva., 132.84**
A cross on the outer corner at the east end of stone door si wagon entrance to Fire House on Second Street about 100 yards of the Everittstown road.

FRENCHTOWN. **Eleva., 131.53**
A cross on the outer corner at the east end of stone door sill of trance to Post Office on Bridge Street opposite Harrison Street.

FRENCHTOWN. **Eleva., 129.32 ft**
A cross on the outer corner at the west end of top step at the ce entrance to the I. O. O. F. building on Bridge Street west of Harri Street.

FRENCHTOWN. **Eleva., 125.48 ft.**
A cross on the extreme east end of stone door sill of center entra to Warford Hotel near the railroad station.

FRENCHTOWN. **Eleva. 116.83 ft.**
A cross on the northwest corner at the north end of west parap of railroad bridge over Cooper Creek about one and one-half miles sou of the station. The cross is at the angle formed by the junction parapet and wing wall.

FRENCHTOWN. **Eleva., 113.46 ft.**
A cross about two feet below the rail of track on the outer corn at the north end of concrete parapet of railroad culvert about t miles south of the station.

FRENCHTOWN. **Eleva., 120.27 ft.**
A cross on the east outer corner of the south end of the concre coping on the Pennsylvania Railroad culvert, over Little Nichisa wick Creek, about 500 feet south of the railroad station.

GLEN GARDNER. **Eleva., 383.77 ft.**
A cross about seven feet below the track on the outer edge at t northwest end of concrete parapet of railroad bridge over a highw about one mile southeast of the station. The cross is at the ang formed by the wing wall.

ARDNER. **Eleva., 469.55 ft.**
ss on the southwest corner of the sixth step from the top at
h end of the west abutment of the Central Railroad bridge, over
ay, about one-half mile north of the railroad station.

ON. **Eleva., 507.10 ft.**
ss on an outcrop of rock about 90 feet east of the center of the
station, seven feet south of the nearest rail of the eastbound
nd 15 feet west of signal No. 562.

ON. **Eleva., 561.64 ft.**
ss on the outer edge at the southeast end of the stone door sill
ntrance to St. Ann's Church.

ON. **Eleva., 519.60 ft.**
ss next to the building on the southeast corner of concrete
oor of the Lackawanna House on the southerly side of the rail-
ck west of the station.

ON. **Eleva., 561.35 ft.**
e northwest end of brick window sill of window on the west
a garage on the easterly side of the Clarksville highway oppo-
h Street.

ON. **Eleva., 583.71 ft.**
ss on the outer edge at the north end of a concrete door sill
public school between Foss Avenue and High Street. The en-
is on High Street.

ON. **Eleva., 467.66 ft.**
ss on the southwest corner of the third stone from top at the
st end of the north abutment of the Delaware, Lackawanna
estern Railroad bridge, over a highway about one mile north
pton.

RIDGE. **Eleva., 377.21 ft.**
ss on the outer edge of the north end of the concrete window sill
all west, rear window of the annex to the Reformed Church, at
ner of the Berkshire Valley road and Church Street.

BRIDGE. **Eleva., 368.70 ft.**
ss on the outer edge of the north end of the stone window sill,
e marble corner stone on the west side of the Methodist Epis-
hurch, at Church and Thomas Streets.

BRIDGE. **Eleva., 371.13 ft.**
e outer edge of the west end of a stone door sill, at the north
e to the High School, being the first entrance from Thomas
on the north face of the building.

BRIDGE. **Eleva., 328.29 ft.**
ss on the southeast corner of stone at the south end of stone
the east side of the railroad about 100 yards south of the

BRIDGE. **Eleva., 330.96 ft.**
ss on the southwest corner of the northeast stone pier on the
ly side of railroad water tank on the east side of the tracks at
tion.

RIDGE. **Eleva., 321.74 ft.**
ss on the outer edge at the west end of middle landing of steps
from Railroad Avenue to the station on the west side of the
at the north end of the building.

HIGH BRIDGE. **Eleva., 317.90 ft.**

On the outer edge at the north end of stone door sill of upstairs e trance to a brick and stone structure occupied by the First Nation Bank on the easterly side of Main Street about 50 feet north of Rai road Avenue. The entrance is the second from an alley at the sout face of the building.

HIGH BRIDGE. **Eleva., 313.04 ft.**

On the outer edge at the north end of concrete step at center entranc to the Post Office, a yellow brick structure on Main Street opposit McDonell Street.

HIGH BRIDGE. **Eleva., 330.75 ft.**

A cross on the level of the girder seat on the southwest corner o second stone step from the top at the westerly end of north abutmen of bridge carrying the High Bridge branch of the Central Railroa over a spur track running to the steel works about 275 yards north o the station and on the east side of the main line.

HOFFMANS. **Eleva., 472.11 ft.**

A cross about 21 feet southerly from the center line of the main trac and 0.54 foot above the rail on the topmost point of rock outcrop abou 165 yards westerly from the railroad station.

HOFFMANS. **Eleva., 446.19 ft.**

A cross 0.8 foot below the floor of the bridge, on the outer corner o the upper of two iron bed plates on the southerly abutment and unde the southerly end of west truss of highway bridge over South Branc of Raritan River just north of the railroad station.

KING STATION, see SIDNEY.

KINGWOOD STATION. **Eleva., 110.40 ft.**

A cross at the inner angle of the northeast wing wall, about tw feet below the level of and eight feet east of the east rail, at the nort east end of the concrete wall of a Pennsylvania Railroad culvert at th station.

KINGWOOD STATION. **Eleva., 108.18 ft.**

A cross on the wall, directly above the crown of the arch, and abou two feet below, and 15 feet east of the east rail at a concrete arch cu vert carrying the Pennsylvania Railroad over Warford Creek, abou one-half mile south of the station.

LAMBERTVILLE. **Eleva., 70.21 ft.**

RTVILLE. **Eleva., 71.55 ft.**
ss about one foot below the rail of track on the outer corner westerly end of south concrete abutment of Pennsylvania Rail-idge (Belvidere Division) over a stream about three-quarters rtherly from the station. The bridge is a two span steel girder e at the spillway of the Raritan Canal feeder.

RTVILLE. **Eleva., 70.52 ft.**
ss on the inner corner at the north end of concrete retaining tween the track and canal feeder about 80 yards north of the station.

RTVILLE. **Eleva., 69.00 ft.**
ss on the outer corner of granite seat of the north steel truss north end of east abutment of highway bridge over the Dela-ver at the railroad station.

WNE. **Eleva., 174.52 ft.**
ss at the inner angle formed by the abutment and wing wall ast end of north concrete abutment of Lehigh Valley Railroad Clinton Branch) over a small stream about three-quarters mile the station.

WNE. **Eleva., 197.46 ft.**
ss on the northwest corner of stone base of the northwest steel of water tank about 30 yards south of the main line tracks of igh Valley Railroad and about 170 yards west of the station. e is the one furthest west of the station and nearest the tracks.

WNE. **Eleva., 171.78 ft.**
ss on the girder seat, about 3.5 feet below the level of and four t of the rail, on the east end of the south concrete abutment of igh Valley Railroad bridge (Clinton Branch) over a branch of ranch of Raritan River, about one-half mile north of the station.

WNE. **Eleva., 178.14 ft.**
ss about four feet east of and about four feet below the east l on the southerly corner of the stone supporting the north end east truss of a bridge over Cakepoulin Creek on the Clinton of the Lehigh Valley Railroad, one-fourth mile north of the

WNE. **Eleva., 196.64 ft.**
ss on the outer corner of the stone supporting the easterly end orth truss, about six feet northeast of, and six feet lower than th rail at the north end of the east abutment of the Lehigh Railroad bridge over Cakepoulin Creek, 1,000 feet west of the

ON. **Eleva., 283.91 ft.**
ss on the northwest corner of the second step from the top of thwest wing wall of the west abutment of a stone arch bridge, ; the Central Railroad over a highway, about 500 feet east of ion.

ON. **Eleva., 298.19 ft.**
ss cut in the outer edge at the east end of stone door sill of the oom of Cushetunk Mountain creamery. The entrance is on the ing the railroad station, and is the most easterly entrance.

ON. **Eleva., 301.30 ft.**
ss on the northwest corner of the third step from the top at th end of the west abutment of a bridge carrying the Central l over a highway, about 1,000 feet west of the station.

LEBANON. **Eleva., 233.75 ft.**
A cross on the northeast corner of the second stone step from th bottom of several steps forming the north end of west abutment o Central Railroad bridge over a small stream about one and one-hal miles east of the station. The bridge is about 100 yards west of highway crossing.

LEBANON. **Eleva., 259.50 ft.**
A cross on the west end of concrete cap of the north parapet railroad culvert 0.4 mile east of the station. The cross is at the inn angle formed by the junction of the parapet and wing wall.

LEBANON. **Eleva., 257.55 ft.**
A cross on the southeast corner of stone on the east end of sou abutment of highway bridge over a stream about 85 yards north of t station.

MT. AIRY. **Eleva., 137.35 ft.**
A cross on the fourth stone step from the bottom of the south abutm of the bridge, over the highway, at the west side of the Flemingt branch of the Pennsylvania Railroad.

NEW GERMANTOWN. **Eleva., 260.57 ft.**
Highest point of a boulder at the edge of the concrete sidewalk northeast corner of the intersection of the main street and the ro leading to the railroad station.

NEW GERMANTOWN. **Eleva., 163.10 ft.**
A cross on the southeast corner of stone at the east end of nor abutment of steel truss highway bridge over Lamington River abo two miles northeast of New Germantown and one-quarter mile nort east of Sutton. The bridge is about 100 yards westerly from the o Rockaway Valley Railroad tracks.

NEW GERMANTOWN. **Eleva., 254.26 ft.**
A cross about one-half foot below the door sill and one-third foot o from the riser on the north end of a large concrete step at the entrance the Methodist Episcopal Church on Main Street.

NEW GERMANTOWN. **Eleva., 205.80 ft.**
A cross on the center of the west wall of a concrete culvert about feet north of the street, leading from the railroad station to Main Stree near the cemetery.

NEW GERMANTOWN. **Eleva., 152.53 ft.**

OWN. **Eleva., 409.09 ft.**
ss on the outer corner at the west end of north abutment of ' bridge over a branch of Cakepoulin Creek about three-quarter st of Pittstown. The bridge is on a road leading northerly and : from its intersection with the main highway to Everittstown.

RSVILLE. **(See Somerset County.)**

ROCK. **Eleva., 85.55 ft.**
ss on a rounded corner of a stone holding the northeast gate at canal feeder, about 200 feet westerly from the railroad station. ss is about five feet south of the south edge of the bridge.

ROCK. **Eleva., 89.24 ft.**
ss on the northwest corner of the west concrete cap of an arch about 100 feet southeast of the station of the Pennsylvania 1.

ROCK. **Eleva., 92.27 ft.**
r bolt on the southerly end of the northeast parapet of con- rch culvert under the railroad about 0.3 mile northwest of the

ROCK. **Eleva., 88.47 ft.**
ss nine feet from the rail of track and about one foot lower on er corner at the south end of west stone abutment of railroad over stream about one and one-quarter miles easterly from the The cross is on the top step of several stone steps forming g wall.

IGSBURG. **Eleva., 383.90 ft.**
ss ten feet from the girder on the outer corner of the bridge seat east end of southerly stone abutment of Central Railroad bridge highway about one and one-quarter miles northeast of High

IGSBURG. **Eleva., 441.94 ft.**
ss 1.5 feet from the girder, near the outer corner of stone on ests the southerly end of east girder of the Central Railroad over South Branch of Raritan River about two and one-half miles st of High Bridge.

f. **Eleva., 252.72 ft.**
ss on the girder seat at the south end of the east abutment of bridge (Pittstown Branch) over a small stream at the pond houses about three-quarters mile westerly from the station.

f. **Eleva.., 261.54 ft.**
ss on the west end of south abutment of steel highway bridge ikepoulin Creek near King's Mill, about one-eighth mile east of tation of the Pittstown branch of the L. V. R. R. The bridge t 100 yards north of the track.

f. **Eleva., 262.15 ft.**
ss on the center door sill of basement entrance in the center the north side of King's Mill about one-eighth mile east of ation on the Pittstown branch of the L. V. R. R.

f. **Eleva., 282.59 ft.**
ss on the outer corner of stone seat of wooden truss at the east- l of northerly abutment of highway bridge over Cakepoulin Creek) yards northwest of King Station on Pittstown branch of Lehigh Railroad.

'. **Eleva., 216.31 ft.**
ss about one foot below the level of bridge floor on northwest t the west end of the south abutment of a highway bridge at the station.

SIDNEY. **Eleva., 229**
A cross 18 inches below the level of floor at the northwest c the west stone abutment of the highway bridge, about one-fou west of the railroad station.

STOCKTON. **Eleva., 83**
A cross about six feet from the rail of track and about one fo on the outer corner at the northeast end of northwest concrete a of railroad bridge over Wickecheoke Creek about one-half mil west of the station.

STOCKTON. **Eleva., 7**
A cross about 3.5 feet north of the north truss, at the north e east abutment of a small bridge, over the canal lock, about 1 north of the railroad station.

STOCKTON. **Eleva., 7**
A cross about two feet below the rail of track on the outer c the northwest end of concrete cap of the northeast parapet of culvert about 200 yards northwest of the station.

STOCKTON. **Eleva., 8**
A cross on the outer corner at the northwest end of stone of the center entrance to the hotel on the main street about 1 northeast of the railroad station.

STOCKTON. **Eleva., 8**
A cross on the outer edge at the north end of the second step bottom, leading up to the Stockton Baptist Church.

STOCKTON. **Eleva., 7**
On the east end of the sill of the second window from the we building, in the south face of the basement of the Presbyterian

STOCKTON. **Eleva., 7**
A cross about five feet from the rail of track and about t below on the outer corner of stone at the northeast end abutment of steel girder bridge carrying the railroad over t feeder about five-eighths of a mile south of the railroad station

STOCKTON. **Eleva., 7**
This is railroad B. M. No. 10, a bolt in the stone at the s end of the north abutment of the bridge which carries the Pen Railroad over the canal feeder, about five-eighths of a mile sou [redacted]

E FALLS. Eleva., 102.13 ft.
s on the northeast corner at the east end of the southwest wing a concrete bridge, a few feet south of the railroad station.

E FALLS. Eleva., 101.33 ft.
s seven feet from the rail of track and about two feet lower uter corner of stone at the north end of east parapet of railroad lge about one-half mile south of the station.

E FALLS. Eleva., 101.92 ft.
s about six feet from the rail of track on the outer corner of cap at the north end of west parapet of concrete arch bridge car- railroad over a stream about three-quarters mile south of the

IOUSE. Eleva., 171.57 ft.
s on the southeast corner of the third stone step from the top iber of steps at the southwest end of the northwest abutment d bridge over a private road about 500 feet east of the station.

IOUSE. Eleva., 172.24 ft.
er bolt in a stone at the north end of the east abutment of ral Railroad bridge, over a private way about 500 feet east of on.

IOUSE. Eleva., 177.09 ft.
s on the northwest corner of the northwest stone pier supporting f water tank just west of the station on the southerly side of the

IOUSE. Eleva., 178.19 ft.
s on the outer edge at the west end of the stone door sill at the entrance to the railroad station.

IOUSE. Eleva., 219.41 ft.
per bolt in the concrete foundation of a signal for westbound bout one and three-quarters miles west of the railroad station.

IOUSE. Eleva., 163.14 ft.
s in line with the southwest face of the building projected south- on the outer edge of a retaining wall at the highway on the t side of the Reformed Church.

IOUSE. Eleva., 168.16 ft.
s cut on the outer edge at the east end of the stone door sill at entrance to the Reformed Church.

IOUSE. Eleva., 128.52 ft.
s 0.6 foot from the northwest end of the northeast parapet of erstown highway bridge over Rockaway Creek about three mile northeast of the New Jersey Central Railroad station. ge is on the northeast edge of the village and about 120 yards t of the Rockaway Valley Railroad track.

[illegible]

N. [illegible]
t station.

N. [illegible]
o building at the [illegible] store about [illegible]

[illegible]

CALIFON. **485.5**
North rail of crossing about one-half mile northeasterly from station. The crossing is the one nearest the dam across the river.

HAMPTON. **508.0 ft**
Frog at junction of D., L. & W. and N. J. Central railroads.

HIGH BRIDGE. **329.4 ft.**
Rail at station.

HOFFMANS. **472.0 ft.**
South rail of main track at crossing.

HOFFMANS. **471.0 ft.**
A cross on concrete base of warning sign, north of the track.

LANSDOWNE. **192.0 ft**
Rail of mainline tracks of L. V. R. R. at station.

PITTSTOWN. **375.8 ft**
Rail of crossing at the station.

SIDNEY. **218.9 ft**
Rail at station.

VERNOY. **490.6 ft**
Northerly rail of main track of crossing at station.

VERNOY. **490.67 ft**
A cross on the concrete base of warning sign, north of track.

WHITEHOUSE. **176.6 ft**
West rail of southbound track at the station.

MERCER COUNTY.[1]

GLENMORE. **Eleva., 199.93 ft**
A cross about two feet below the level of and 25 feet east of east r near the base of a post of iron-pipe railing, at the east end of the no concrete abutment of a bridge over highway and trolley, on the Read Railroad at Glenmore station. The cross is at the corner of the w where it turns at a right angle from the road.

GLENMORE. **Eleva., 186.89 ft**
A cross about six feet below the level of and 15 feet east of the e rail on the east edge of the capstone of a stone arch at the easterly s

TSTOWN. **Eleva., 92.00 ft.**
ross on the outer corner and on the layer of stones forming the
seat at the south end of west abutment of P. R. R. bridge over
Street. The cross is 18.feet from the girder.

rSTOWN. **Eleva., 112.13 ft.**
)ss on the east end of door sill of most westerly entrance on Stock-
eet to First Methodist Church at the corner of Church Street.

STOWN. **Eleva., 87.78 ft.**
ıss on the south end of brownstone door sill of corner entrance
.ingham's drug store on the southwest corner of Main and Stock-
eets.

STOWN. **Eleva., 86.36 ft.**
ss on the outer corner at the south end of granite door sill of
reet entrance to First National Bank, on the west side of Main,
)0 feet north of Stockton Street.

STOWN. **Eleva., 116.87 ft.**
ss on the southerly end of basement window sill of the third
from the southwest corner on the westerly face of public school.
ıcture is about 350 yards southwest of the P. R. R. station, on
htstown-Windsor road.

STOWN. **Eleva., 118.10 ft.**
ss on the southwest corner of concrete base of water supply pipe
ines, at the junction of Amboy Division of P. R. R. and the
ton-Hightstown R. R., about one mile southwest of the station.
ucture is between the tracks, and about 50 yards below the
ouse.

'ELL. **Eleva., 152.89 ft.**
ss on ledge of stone, 1.8 feet below the cap, at the center of the
arapet of highway bridge over small stream about one mile
st of the town on the Stoutsburg road. The bridge is north-
a crossroad nearby.

'ELL. **Eleva., 152.23 ft.**
ss near the outer corner of bridge seat at the northerly end of
abutment of a steel truss highway bridge about three-fourths
theast of the town on the Stoutsburg road. The bridge is south-
a crossroad nearby leading to Mount Rose.

'ELL. **Eleva., 230.13 ft.**
ss on the westerly corner at the southwest end of stone pier sup-
wooden frame of overhead highway bridge spanning the Reading
l one mile southwest of the station. The mark is below the ce-
p of pier and is about 0.75 feet above the railroad track.

'ELL. **Eleva., 208.25 ft.**
ss on the capstone on the southerly end of the westerly abut-
f Reading Railroad bridge about 350 yards southwest of the
The mark is about four feet from the nearest rail and about
ıes lower.

'ELL. **Eleva., 203.30 ft.**
ss on the northeast end of brownstone door sill of the most east-
rance on the southerly face of the Reading Railroad station.

'ELL. **Eleva., 201.75 ft.**
ss on the outer edge at the northerly end of a brownstone door
he post office next to Central Hotel on Broad Street, opposite
ell Avenue.

'ELL. **Eleva., 196.63 ft.**
nt on the outer edge at the southerly end of a brownstone door
ectly below the letter "H" in Hopewell, at the entrance to the
of the Hopewell National Bank.

HOPEWELL. **Eleva., 19**
A cross on the southerly end of the bluestone door sill, under t
at the entrance to Cavalry Baptist Church.

HOPEWELL. **Eleva., 19**
A cross on the outer edge at the northeasterly end of the br
floor sill at the southwesterly rear entrance to the Hopewell Hig

KINGSTON. **(See Middlesex C**

MILLSTONE AQUEDUCT. **Eleva., 5**
A triangle cut in the center of the memorial plate at the t
south end of the west abutment of the aqueduct carrying the
and Raritan Canal over Millstone River, two miles south of Kin

PENNINGTON. **Eleva., 18**
A cross on the northwest corner of the lowest stone step at
end of the south abutment of the Reading Railroad bridge, ove
way, about one and one-quarter miles north of the railroad s

PENNINGTON. **Eleva., 19**
A cross on the south end of the stone door sill at the entran
ladies' waiting room in the west face of the Reading Railroad st

PENNINGTON. **Eleva., 21**
A cross on the south end of the door sill at the Main Street en
the First National Bank on the northeast corner of Delaware A

PENNINGTON. **Eleva., 20**
A cross on the outer corner at the north end of the bluestone
at the entrance to the basement of the administration buildin
nington Seminary. The entrance is on the left side and is im
under the porch steps of the upper entrance.

PENNINGTON. **Eleva., 12**
A cross at the outermost corner of a large capstone, about t
north of truss, and about nine and one-half inches lower than t
floor, on the north end of the west abutment of the bridge, car
highways over Jacob's Creek, about two and one-half miles west
ington, on the road to Titusville.

PENNINGTON. **Eleva., 18**
A cross on the outer edge of capstone and at the center of wes
of the most southerly arch of railroad culvert at Baldwin's Cr
two-fifths mile northerly from the Reading station. The mark is

N. **Eleva., 203.70 ft.**
n the highest stone step 1.6 feet from the hinge of east iron in northerly entrance to Palmer Physical Laboratory. The he left side as you enter.

N. **Eleva., 167.79 ft.**
n the east end of the stone door sill of the west entrance on ly side of the Geological Laboratory. The cross is imme- e beveled portion of base stone of archway.

N. **Eleva., 194.31 ft.**
n the east end of the granite door sill at the tower entrance to ist Episcopal Church. The cross is five and one-half inches e door jamb, and two inches east.

ILLE. **Eleva., 87.34 ft.**
n the outer corner of the second stone step of four steps southerly end of west wall of P. R. R. arch culvert over Miry three-quarters mile northeast of the station. The cross is n feet below the rail.

ILLE. **Eleva., 91.89 ft.**
n the center of cap of southerly parapet of concrete highway Miry Run, about three-quarters mile northeast of the station e P. R. R. track. The cross is directly over the center of the stream.

ILLE. **Eleva., 125.24 ft.**
n the outer edge at the northerly end of bottom cement step northerly entrance on the northeast face of hotel, opposite station. The building is on the westerly side of Robbins- on Square highway.

ILLE. **Eleva., 125.47 ft.**
n the inner corner at the northwest end. and directly below a window, of top concrete step at entrance to office of the at the railroad station. The building is on the westerly Robbinsville-Allentown highway.

JRG. **(See Somerset County.)**

E. **Eleva., 63.23 ft.**
ut on the east end of the stone door sill at the front entrance resbyterian Church.

E. **Eleva., 58.63 ft.**
on the southwest corner of a stone on the west end of the ment of a bridge in the rear of the Presbyterian Church, e Pennsylvania Railroad over a dry water course.

E. **Eleva., 61.79 ft.**
n the westerly end of door sill of main entrance to the Hotel ear the railroad station.

LE. **Eleva., 60.47 ft.**
enter of a brownstone monument on the north side of the d about five feet westerly from the nearest rail of the rail- station. (The stone is leaning slightly from the vertical.)

. **Eleva., 44.86 ft.**
on the outer corner at the south end of second step from of the most southerly set of steps leading from Third Avenue tate Prison. The entrance is about 115 yards south of Fed- .

. **Eleva., 52.61 ft.**
le cut in the northeast corner of the nost northerly coping e west lock wall of the prison lock of the Delaware and Rari-

TRENTON. **Eleva., 61.82**
A cross on the southeast corner of stone on the south end of abutment of railroad bridge at the junction of the canal and feeder block north of Perry Street.

TRENTON. **Eleva., 51.58 ft.**
A cross near the outer corner on the east end of granite door sill of entrance to the Bell Telephone building on the north side of State Street near the Post Office.

TRENTON. **Eleva., 52.30 ft.**
A cross on the inner corner at the east end of the lower of two steps at entrance to The Trenton Savings Fund Society building on the south side of State Street west of the Post Office.

TRENTON. **Eleva., 54.25 ft.**
On the broad water table, 3.2 feet above the pavement, in the reentrant angle of stone moulding, 1.1 feet south from produced line of the south jamb of the most southerly window on the west side of the United States Government building, at the northeast corner of Montgomery and State Streets. The point is indicated by an arrow head.

TRENTON. **Eleva., 50.34 ft.**
A cross 0.9 foot from the west end of the step, and 0.7 foot in from outside edge, about four inches from the base of the westernmost column, near the west end of the second step from the bottom of the corner entrance to the Mechanics National Bank building at the southwest corner of Warren and State Streets.

TRENTON. **Eleva., 50.43 ft.**
A cross 0.6 foot from the outer edge and about 1.2 foot from the east end of top step and landing at the State Street entrance to The School of Industrial Arts of the City of Trenton on the corner of State and Willow Streets.

TRENTON. **Eleva., 51.18 ft.**
A point 0.5 foot diagonally in from the southeast corner of the base of the easternmost granite column at the main entrance to the State House.

TRENTON. **Eleva., 62.66 ft.**
A cross near the outer corner at the south end of granite door sill of entrance on the east face of the City Hall.

TRENTON. **Eleva., 61.49 ft.**
A cross on the outer corner of a large stone at the west end of steps, and about five feet out from the iron gate at the State Street entrance to the City Hall.

NDSOR. Eleva., 102.01 ft.
op of bell, at the southerly end of 72 inch cast iron pipe culvert under railroad, about three-quarters mile northeast of the station. The t is about four and one-half feet below and 15 feet from the rail.

DSOR. Eleva., 98.54 ft.
cross on the outer corner at the southerly end of white sandstone sill of most northerly entrance on the west face of Washington ship public school. The structure is about 240 yards southeast of R. R. station and sets back easterly from the Windsor-Carson's highway.

SOR. Eleva., 111.57 ft.
oss on the outer corner at the northerly end of brown stone door enrance to Methodist Church. The building was constructed in nd is about 325 yards northwest of the railroad station along the or-Edinburgh highway.

SOR. Eleva., 88.36 ft.
oss nine feet from and 0.5 foot below the rail, at the southeast end erly concrete abutment of P. R. R. bridge, over Assanpink Creek. one-half mile southwest of the station.

VILLE. Eleva., 56.88 ft.
oss 0.5 foot below the rail and one foot from the southeast end of y concrete abutment of P. R. R. bridge over Back Creek, about d one-quarter mile northeast of the station.

VILLE. Eleva., 59.15 ft.
oss on the outer corner and at the base of a wooden post, on the rly end of concrete floor of porch of Anderson Bros.' building. The ire is of wood and is on the westerly side of the Yardville-Cross-road about 75 yards southerly from the P. R. R. crossing.

VILLE. Eleva., 56.59 ft.
oss on the outer edge at the northerly end of door sill of upstairs ffice entrance, on the northeast face of Zee Zee Rubber Co.'s g. The structure is on the southwest side of the Yardville-Cross-highway, and sets back about 200 feet southwest of the road.

VILLE. Eleva., 35.33 ft.
oss on the outer edge of the girder seat and four and one-half feet he girder, on the west end of south concrete abutment of Penn. bridge over Crosswicks Creek, about one-half mile southwest of

SECONDARY BENCH MARKS.

'STOWN. 100.8 ft.
at station.

NSVILLE. 122.2 ft.
of crossing at the station.

SOR. 101.0 ft.
of crossing at the station

VILLE. 55.8 ft.
at station.

MIDDLESEX COUNTY.[1]

LLEN. Eleva., 57.29 ft.
oss on the base stone and on the level of the door sill, immedi-below the corner of a show window of No. 384 North Avenue. ilding is about 50 yards southwest of Prospect Street and is northwest side of North Avenue.

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[1] Bulletins 17 and 19 for chief lists of primary bench marks in this county.

NEW MARKET. **Eleva., 47.32**
A cross cut on the concrete cap at the south end of pier of R. R. bridge over small stream about three-quarters of a mile we erly from the station.

NEW MARKET. **Eleva., 52.73 ft.**
A cross on the concrete walk immediately below the northwest corner of the New Market Supply Company's building southerly from the railroad station.

PERTH AMBOY. **Eleva., 64.01 ft.**
A cross on the north end of window sill of small window on the High Street face and 12 feet from the rear entrance to the First Presbyterian Church at the corner of High and Market Streets.

WOODBRIDGE. **Eleva., 17.18 ft.**
A cross cut on the north end of stone sill of the south door on the east side of the Pennsylvania Railroad station.

SECONDARY BENCH MARKS.

BROWN. **53.8 ft.**
East rail at the station.

CRANBURY. **118.6 ft.**
Rail at station.

DAYTON. **105.3 ft.**
North rail of main track of crossing at the station.

EAST SPOTSWOOD. **27.1 ft.**
Rail at station.

HELMETTA. **41.9 ft.**
North rail of crossing just east of the station.

HOFFMAN. **81.1 ft.**
North rail of crossing at the station.

JAMESBURG. **82.3 ft.**
Rail at station.

JAMESBURG. **52.2 ft.**
Rail at Lower Jamesburg station.

KINGSTON. **56.3 ft.**
Rail at station.

H PLAINFIELD. **66.0 ft.**
th rail at the station.

EY. **84.3 ft.**
of crossing at the station.

MONMOUTH COUNTY.[1]

RE. **Eleva., 63.21 ft.**
ss 0.7 foot out from the building, on the easterly edge of cement ding to concrete switch-house on the north side of the railroad bout 200 yards west of the station.

E. **Eleva., 48.73 ft.**
s on the outer corner, at the easterly end of southwest parapet ulvert under the railroad just west of the station.

E. **Eleva., 52.00 ft.**
marble monument projecting one and one-half feet above the and marking a property corner on the easterly side of the race- ut 25 yards in front of and southwest of the railroad station.

HURST **Eleva., 14.06 ft.**
s on the south end of door sill of most northerly entrance, on the e of the Atlantic Coast Electric Co.'s car barn, at the southeast Main Street and Elberon Avenue. The entrance is a single door ear the northwest corner of the building.

HURST. **Eleva., 17.85 ft.**
s on the south end of door sill of most southerly entrance, on the e of the railroad station. The structure is east of the track and enters the express company's office.

TOWN. **Eleva., 83.36 ft.**
s on the inner corner at the north end of cement porch floor of ne house on the Robbinsville road, about 100 yards from the ho-

TOWN. **Eleva., 87.01 ft.**
s on the outer corner at the north end of window sill of the most y of two windows on the west face of the post office, a cement ructure, on the Robbinsville road 50 yards from the hotel.

TOWN. **Eleva., 70.11 ft.**
s on the southeast corner of bridge seat at the southerly end of utment of highway bridge over spillway of pond 100 feet west of ntown Roller Mills.

TOWN. **Eleva., 103.63 ft.**
s on the outer corner at the southerly end of flagstone door sill of trance to the Presbyterian Church, a red brick building on the Davis Station.

TOWN. **Eleva., 86.19 ft.**
ss on the outer corner at the southwest end of brown sandstone l of corner and main entrance to the Farmers National Bank.

WOOD. **Eleva., 63.70 ft.**
ss six inches from the building, on the westerly edge of cement ading to concrete switch-house, at the crossing, just west of the station.

WOOD. **Eleva., 68.93 ft.**
s on the westerly end of bluestone window sill of window on the y face and at the southwest corner of brick store building, at s of the road, near and west of the railroad station. The sill is above the ground.

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[1] edes all previous lists.

ALLENWOOD. **Eleva., 63.72**
A cross near the westerly end of cement door sill of eastern
double door entrance, on the southwest face of the blacksmith sho
red brick structure at the forks of the road, easterly from the railr
station. The floor of the building is the same level.

ALLENWOOD. **Eleva., 65.00 ft**
A cross on the northeast corner of concrete base of bell signal, at
crossing, easterly from the railroad station.

ALLENWOOD. **Eleva., 80.43 ft**
A cross on the northeast corner of concrete base of signal on the no
side of the railroad, about one and one-half miles east of the station. T
signal is just east of the mile post 31-2.

ASBURY PARK. **Eleva., 25.26 ft**
A cross on the outer corner at the east end of top step at the girls'
trance to school building on Main Street, near Wesley Lake, in Oc
Grove.

ASBURY PARK. **Eleva., 19.64 ft**
A cross on the west end of door sill of main entrance on Lake Ave
to Armory of Company H, 3d Regiment, N. G. N. J.

ASBURY PARK. **Eleva., 24.34 ft**
A cross on the outer corner, at the west end of brownstone door
of entrance to Sea Coast Building, on the corner of Bond Street and M
tison Avenue.

ASBURY PARK. **Eleva., 25.05 ft.**
A cross on the outer corner at the west end of cement floor of alco
at the boys' entrance to public school, corner of Somerfield Avenue a
Bond Street. The entrance is on the south face of the building.

ASBURY PARK. **Eleva., 24.58 ft.**
A cross on the outer corner at the east end of bluestone door sill
rear entrance, on the southerly face of the First M. E. Church, corner
First and Grand Avenues.

ASBURY PARK. **Eleva., 24.69 ft.**
A cross on the outer corner at the south end of first step below t
door sill of Grand Avenue entrance to Trinity P. E. Church on the corn
of Grand and Asbury Avenues.

ASBURY PARK. **Eleva., 25.90 ft.**
A cross on the outer corner at the extreme east end of top granite st

N BY THE SEA. Eleva., 19.79 ft.
the outer edge, and at the face of the building, of second step from op step or slab of front entrance to St. Elizabeth's Church, two directly east of the railroad station.

IAR. Eleva., 21.70 ft.
ross on the east end of bluestone door sill of entrance, on the face of office of the Coast Gas Co., a brick building on 16th e, just west of the railroad track.

AR. Eleva., 18.34 ft.
oss on the outer edge, at the west end of door sill of entrance to room on the south face of the Belmar water works on 12th e, west of the railroad tracks.

AR. Eleva., 23.57 ft.
oss next to the door jamb, at the south end of a large brown one step at the main entrance to school building, on the corner treet and 12th Avenue.

AR. Eleva., 17.24 ft.
oss on the outer edge at the south end of door sill of entrance, west face of the railroad station.

AR. Eleva., 20.12 ft.
oss on the outer edge at the east end of top granite step and sill ance to the Coast Gas Co.'s Building on 9th Avenue, about 100 ast of the railroad.

AR. Eleva., 16.86 ft.
oss on the southwest end of door sill of corner entrance to the ational Bank on the southeast corner of F Street and 9th Avenue.

EVELT. Eleva., 162.77 ft.
oss on the level of the truss seat and on the northeast corner north end of west concrete abutment of steel highway bridge over d just south of the station.

EVELT. Eleva., 161.93 ft.
oss on the east end of brownstone door sill and step of the most ly entrance on the south face of the Reformed Dutch Church.

LEY BEACH. Eleva., 26.12 ft.
oss five inches from the east edge and near the center of bluestone the south pier supporting iron post of roof over driveway, at ce, on the east face of the railroad station.

LEY BEACH. Eleva., 24.81 ft.
oss on the west end of door sill of most westerly entrance, on the face of Borough Hall, a brick structure on north side of the park railroad station.

LEY BEACH. Eleva., 23.61 ft.
oss on the extreme right and on the level of the bottom step, at e of brick support of arch of Bringley Avenue entrance to public east of the railroad station. The cross measures 7.5 feet from a rojected below the keystone of the arch.

EY BEACH. Eleva., 23.59 ft.
oss at the face of the building and on the south end of granite l step of tower entrance, on the west face of Catholic Church, two east of the railroad station on Bringley Avenue.

RIDGE. Eleva., 118.94 ft.
of red brick foundation at the center of the north face of the railation.

CREAM RIDGE. **Eleva., 122.35 ft.**
Northwest bolt holding gasoline stand to concrete foundation on th southerly side of the highway about 50 yards east of the railroad.

CREAM RIDGE. **Eleva., 134.51 ft.**
A cross next to the building on the north end of the first cement ste below the door sill of entrance on the west face of the church.

DAVIS. **Eleva., 124.79 ft.**
A cross on the outer corner of concrete counterfort at the northwe corner of foundation of creamery at the railroad station.

DEAL BEACH. **Eleva., 32.68 ft.**
A cross on the north end of door sill of northerly entrance, on the we face of the railroad station, east of the track.

DEAL BEACH. **Eleva., 30.33 ft.**
A cross on the center of cement window sill of most westerly windo on the north face of the N. J. Water and Light Co.'s power house o the east side of the railroad, about three-quarters mile north of t station.

ELBERON. **Eleva., 37.39 ft.**
A cross on the north end or door sill of most southerly entrance o the west face of the railroad station, east of the track.

ENGLISHTOWN. **Eleva., 71.64 ft.**
A cross on the corner at the westerly end of southerly concrete wa of small highway bridge over brook about 200 feet northeast of the ra road track on the Englishtown-Bergen Mills road. The highway cross the track about one-quarter mile northwest of the station.

ENGLISHTOWN. **Eleva., 71.86 ft.**
A cross 2.6 feet above the crest of the spillway and one foot out fro the post of bridge railing, at the easterly end of southerly concre abutment of steel highway bridge over stream, at the old mill on Ma Street. The overflow of a lake is at the bridge.

ENGLISHTOWN. **Eleva., 72.97 ft.**
A cross on the outer corner at the north end of concrete slab formi the top step of three steps at the main entrance to Sanford Memorial M. Church, on the west side of Main Street.

ENGLISHTOWN. **Eleva., 72.67 ft.**
A cross on the outer edge at the southerly end of door sill of corn entrance to First National Bank on the southwest corner of Main a

INGDALE. **Eleva., 71.77 ft.**
ross on the level of the girder seat and on the outer corner at the
rly end of southeast concrete abutment of P. R. R. bridge over
Bog Brook, about three-quarters mile northwest of the station.

INGDALE. **Eleva., 74.15 ft.**
ross on the southeast edge of cement walk leading to concrete
house, at the crossing, about one-quarter mile northwest of the
along the Pennsylvania Railroad. The cross is at the entrance
inches below the sill.

INGDALE. **Eleva., 74.29 ft.**
ss six inches from the north end of cement sill of entrance on the
ace of baggage room at the railroad station. The cross is im-
ely under the sliding door and the entrance faces the N. J. Central

INGDALE: **Eleva., 75.88 ft.**
oss on the northwest corner of cement block anchor of guy wire
k at A. C. Soper Co.'s plant, about 200 yards north of the rail-
ation. The anchor is on the west side of the highway and west
Central R. R. tracks.

INGDALE. **Eleva., 79.49 ft.**
oss on the outer corner at the northerly end of cement door sill
le door entrance to the engine house of the Fire Department, a
nd shingle structure built in 1911, on Main Street.

INGDALE. **Eleva., 81.44 ft.**
edge of marble corner stone at the south corner of the Fire De-
nt building on Main Street. The date on the stone is 1911.

INGDALE. **Eleva., 44.04 ft.**
oss on the level of the girder seat and on the southeast corner of
e stone at the southerly end of westerly abutment of P. R. R.
over a stream about one mile southeast of the station. The cross
t feet from the girder.

HOLD. **Eleva., 186.23 ft.**
oss cut two and one-half inches south of the intersection of the three
formed by the three most southerly stones in the south corner of
ge triangular base of the Monmouth Battle Field Monument. The
s two and one-half inches south of the north apex of the stone which
n its south sides against the octagonal gun pedestal, which is built
south corner of the triangular base.

HOLD. **Eleva., 181.69 ft.**
uare cut on the northwest end of brownstone door sill of entrance
es' waiting room, on the northeast face of the P. R. R. station.

HOLD. **Eleva., 176.70 ft.**
oss eight feet from the southwest corner, on the base stone of the
building. The structure is on the northerly side of West Main
about 100 yards northeast of the P. R. R., and the cross is on
of the center entrance.

HOLD. **Eleva., 178.49 ft.**
oss on the westerly end of brownstone door sill of entrance to
ational Bank, on the northerly side of West Main Street, about
ds northeast of the P. R. R. crossing.

HOLD. **Eleva., 177.74 ft.**
ss cut on the east end of stone door sill of the Sheriff's office,
he most easterly of two doors in the middle of the front of Mon-
County Court House.

FREEHOLD. **Eleva., 146.**
A cross on the southwest corner of fourth stone step below th
seat at the southerly end of easterly abutment of P. R. R. brid
roadway, about one-half mile easterly from the station. The date
on the face of the stone.

FREEHOLD. **Eleva., 127.**
A copper bolt in the stone cap at the westerly end of southerly
of P. R. R. stone arch bridge over stream, about one and one
miles southeast of the station. The bridge is about 150 yards
from a nighway crossing.

GALILEE. (See MONMOUTH BEACH.)

HIGHLANDS. U. S. C. S. -2. **Eleva., 13.**
A red metal disc in the top of the eastern pier of the railroa
bridge.
(Note: This bench mark is on the southeast wing wall at the
of bridge, near Highland Beach Station.)

HIGHLANDS. U. S. C. S. -3. **Eleva., 202**
This bench mark is a mark on top surface of a heavy gran
near Navesink lighthouse. The post is deeply imbedded and
projects about one and one-half feet above the surface of the gro
is 13 meters (42.6 feet) south of the southernmost tower of N
Highlands lighthouse.

HIGHLANDS. U. S. C. S. -4 (Primary mark D.) **Eleva., 207**
This bench mark is the bottom surface of a square cavity (ab
inch square) cut on a sloping ledge at southeast corner of
southernmost lighthouse tower at Navesink Highlands light.

HOLLYWOOD. (See WEST END.)

HORNERSTOWN. **Eleva., 61.**
A cross on the outer corner of bridge seat at the west end
abutment of highway bridge over a stream just east of the railroa
275 yards north of the station.

HORNERSTOWN. **Eleva., 82.**
A cross on the cement walk at the southwest corner of the build
at the south end of the steps of the church, 100 feet north of th
roads on the road leading to Cream Ridge.

HORNERSTOWN. **Eleva., 71**

ORT. **Eleva., 21.61 ft.**
ross on the north end of bluestone door sill of Broad Street en- to People's National Bank on the west side of Broad, about 200 outh of Front Street.

ORT. **Eleva., 26.60 ft.**
edge and corner of marble cornerstone at the northwest corner of ritan Guard Public Library, on the east side of Broad, about one south of Front Street.

ORT. **Eleva., 35.39 ft.**
oss on the west end of door sill of entrance on the south face and e southwest corner of public school at Broad and Mott Streets.

COMO. **Eleva., 20.95 ft.**
oss on the outer corner at the north end of door sill of most rly entrance on the west face of the railroad station.

BRANCH. (LONG BRANCH CITY.) **Eleva., 11.27 ft.**
oss on the southeast corner at the east end of south concrete t of culvert under Pavilion Avenue at its intersection with Second . The culvert is west of the New Jersey Central Railroad tracks.

BRANCH. (LONG BRANCH CITY.) **Eleva., 21.82 ft.**
oss on the west end of bluestone door sill of Broadway entrance zens National Bank, on the south side of Broadway, 200 feet east rd Avenue.

BRANCH. (LONG BRANCH CITY.) **Eleva., 25.01 ft.**
oss on the outer corner at the south end of door sill of the Third entrance to the New York Telephone building, on the east side rd Avenue, about 100 feet south of Belmont Avenue.

BRANCH. (LONG BRANCH CITY.) **Eleva., 26.42 ft.**
oss on the west end of bluestone door sill of tower entrance on d Avenue to Simpson Memorial M. E. Church, on the southeast of Garfield and Third Avenues.

BRANCH. (LONG BRANCH CITY.) **Eleva., 27.71 ft.**
oss on the outer corner at the south end of top granite step of the ight, at entrance to the Post Office on Third Avenue, opposite d Avenue. The top step is the sixth from the sidewalk and forms ding.

BRANCH. (LONG BRANCH CITY.) **Eleva., 14.93 ft.**
oss on the northwest corner of second stone step from the top on rth end of east abutment of Eatontown branch of Central Rail- ver Long Branch Avenue. The bridge is on the curve of the track est of East Long Branch station, and the stone is the first below der seat.

LARD. U. S. C. S. -8. **Eleva., 13.55 ft.**
metal disc in the top of the northwest pier of the small masonry about 200 meters (about 650 feet) east of the railroad station.

SQUAN. **Eleva., 19.37 ft.**
ss on the outer edge at the easterly end of granite door sill and entrance to the Manasquan National Bank on Main Street, just South Street.

SQUAN. **Eleva., 19.66 ft.**
oss on the cement floor of porch, immediately below the east of the Osborn Hotel, at the corner of South and Main Streets. r of the porch and the sidewalk are on the same level.

SQUAN. **Eleva., 24.93 ft.**
ss on the outer corner at the south end of door sill of most ly entrance, on the west face of Presbyterian Church at the corner h Street and Virginia Avenue.

MANASQUAN. **Eleva., 2**
A cross on the outer corner at the south end of cement ste
of entrance to the Osborn Hardware store, a frame building on
side of Broad Street, about 200 feet north of Main Street.

MARLBORO. **Eleva., 11**
A cross six inches from the outer corner of the stone on wh
the south end of east girder, near the east end of south abu
New Jersey Central Railroad bridge, over stream about three
mile north of the station.

MARLBORO. **Eleva., 15**
A cross on the west end of basement window sill of the most
window on the south face of the Monmouth County Farmers' E
a brick structure east of the railroad track and on the north si
highway, just north of the station.

MARLBORO. **Eleva., 15**
A cross at the door casing on the west end of cement step a
entrance to the office of Abbott Worldley Co., a small brick
west of the track and at the crossing just north of the railroad

MATAWAN. **Eleva., 5**
A cross on the outer corner at the northeast end of door sill o
entrance to the Gehlhaus Building, a brick structure on the
side of Main, at the corner of Little Street. The entrance is
southerly from Little Street.

MATAWAN. **Eleva., 5**
A cross, 3.5 feet above ground, on the northeast end of br
window sill of northernmost window on the Main Street face
Church near Little Street.

MATAWAN. **Eleva., 5**
On the south (outer) corner of polished granite base ston
southwestern pillar at entrance to the Farmers and Merchants
Bank, on the westerly side of Main Street.

MATAWAN. **Eleva., 3**
A cross on the south end of stone door sill of Episcopal C
Main Street.

MATAWAN. **Eleva., 6**
A cross on the northeast end of the northeasternmost basemen

MORGANVILLE. **Eleva., 110.94 ft.**
A cross seven feet above ground on the east end of cement door sill of most westerly entrance, on the north face of the R. V. C. Co.'s factory, on the easterly side of the track about one-quarter mile north of the railroad station. The building is of red brick and is the largest of the plant.

MORGANVILLE. **Eleva., 136.27 ft.**
A cross on a foundation stone projecting beyond the east face of the west brick pier supporting frame of overhead highway bridge over railroad; one-third mile south of the station. The cross is 3.3 feet below the top and two feet from the north end of the pier.

NELSONVILLE. (IMLAYSTOWN STATION.) **Eleva., 115.72 ft.**
A cross next to the building on the west end of cement step at entrance to the post office on the east side of the tracks at the railroad station.

NELSONVILLE. (IMLAYSTOWN STATION.) **Eleva., 114.23 ft.**
On the east end of cement wall in front of the post office at the railroad station.

NELSONVILLE. (IMLAYSTOWN STATION.) **Eleva., 112.36 ft.**
Most easterly bolt in the northwest concrete pier supporting frame of water tank south of the highway and east of the railroad, at the station.

NEW MONMOUTH. (NORTH LONG BRANCH.) **Eleva., 14.82 ft.**
A cross on the south end of door sill of the second entrance from the northwest corner and on the west face of the New Jersey Central Railroad station on Atlantic Avenue and east of the tracks.

NEW MONMOUTH. (NORTH LONG BRANCH.) **Eleva.. 19.42 ft.**
A cross on the west end of brownstone door sill of tower entrance on Atlantic Avenue to Asbury M. E. Church on the northeast corner of Church St. and Atlantic Avenue.

NORTH ASBURY PARK. **Eleva., 14.84 ft.**
On the outer corner at the east end of door sill of the upstairs entrance to a white brick structure on the south side of Fifth Avenue, at the railroad. The building is the first east of the tracks, and the entrance is about 25 feet from the west face.

NORTH ASBURY PARK. **Eleva., 14.14 ft.**
A cross on the outer corner at the south end of door sill of entrance to the waiting room, on the west face of the railroad station, east of the tracks.

NORTH ASBURY PARK. **Eleva., 10.37 ft.**
A cross three and one-half feet from the girder and on the northeast corner of the girder seat, at the east end of south concrete abutment of railroad bridge over Deal Lake, just north of the station. The bridge is the most southerly of two.

OCEAN GROVE. (See ASBURY PARK.)

PORT MONMOUTH. U. S. C. S. -9. **Eleva., 14.11 ft.**
A red metal disc set in the brick wall of a house, which is south of the track and on the east side of the road crossing the track near the station. The bench mark is in the northwest corner of the cellar wall.

RED BANK. **Eleva., 45.77 ft.**
A cross cut on the south end of front door sill of the old First National Bank Building on Broad Street.

RED BANK. **Eleva., 44.25 ft.**
A cross on the outer edge at the north end of door step and sill of entrance to No. 40 Broad Street, occupied by the Red Bank Register. The building is on the west side of Broad, about 50 feet north of White Street.

RED BANK. **Eleva., 43.**
On the extreme outer corner at the south end of granite step of
Street entrance to the Red Bank Trust Co., a marble structure
east side of Broad Street, just north of Monmouth Avenue. Th
is six feet south of the south door hinge and 0.6 feet above the si

RED BANK. **Eleva., 43.**
A cross cut on northeast corner of lower stone step of Mo
Avenue entrance of M. E. Church, on the corner of Broad Street.

RED BANK. **Eleva., 41.**
On the outer corner at the west end of bluestone door sill of u
entrance to Navesink Lodge No. 39, I. O. O. F., a yellow brick st
of three stories on the north side of Monmouth Avenue, about 2
west of Broad Street.

RED BANK. **Eleva., 40.**
On the outer corner, at the extreme west end, and six feet west
center of entrance of marble base stone of Patterson Building,
story structure used as the Post Office. The building is on the
side of Monmouth Avenue, about 100 yards west of Broad Street.

RED BANK. **Eleva., 43.**
A cross on the west end of bluestone door sill of driveway en
at the northeast corner of St. James Catholic Church, on Broad
south of Monmouth Avenue. The entrance is under the porch,
extends across the driveway.

SANDY HOOK. U. S. C. S. -10. **Eleva., 8.**
A bench mark of the Ordnance Department near the office buil
the Sandy Hook proving grounds and about 60 meters (197 feet)
west of a small water tank which is north of and across the r
tracks from the office building. The bench mark is a copper bolt
top of a granite post set in the ground and surrounded by cement

SANDY HOOK. U. S. C. S. -11. **Eleva., 19.**
This bench mark is a cross on the head of a copper bolt driv
the wall of the main lighthouse, at Sandy Hook. The main lig
is an octagonal tower, resting upon a circular foundation of
stones. This foundation projects on all sides about 8 inches, bey
base of the tower, so as to form a sloping ledge. The copper b
few inches westward of the northwest angle, and nine and one-
inches above the ledge.

IRIGHT. Eleva., 7.89 ft.
oss on the outer edge at the north end of bluestone door sill of
e, on the west face of the railroad station on the west side of the
near the east end of the bridge over the Shrewsbury River.

RIGHT. Eleva., 7.09 ft.
ss on the center and topmost point of the southeast concrete base
ing metal frame flag pole at L. S. S. No. 99, on the west side of
road tracks about one mile north of Sea Bright Railroad station.

IRT. Eleva., 20.36 ft.
ss on the northeast corner of southeast concrete pier supporting
tic signal frame at the crossing just below the railroad station.
r is east of the tracks.

RT. Eleva., 19.49 ft.
ss on a small ledge of stone chimney at the north end of Gov-
cottage, near the railroad station. The cross is about 0.7 foot
he water table of building and 0.4 foot from the west edge of the
r.

IRT. Eleva., 26.98 ft.
ss on the southwest corner of the southwest concrete pier sup-
frame of water tank west of the railroad tracks and about 300
orth of the station.

IRT. Eleva., 10.52 ft.
ss, 3.3 feet from the girder and 3.5 feet above the girder seat,
northeast corner at the east end of south concrete abutment of
l bridge over Wreck Pond, about three-quarters mile north of the

G LAKE BEACH. Eleva., 12.97 ft.
ss on the center of cement cap of west parapet of railroad cul-
er North Branch of Wreck Pond, about one-third mile south of the

G LAKE BEACH. Eleva., 17.48 ft.
ss on the east end of cement door sill of front entrance to Spring
aterworks pumping station, east of the railroad track about 300
outh of the station.

G LAKE BEACH. Eleva., 22.72 ft.
ss on the outer corner at the north end of white sandstone door
the south entrance, on the west face of the railroad station, east
tracks.

G LAKE BEACH. Eleva., 28.16 ft.
ss on the north end of bluestone door sill on the west face and
northwest corner of brick school building at 5th and Warren
s. The structure is diagonally across the park from the railroad

G LAKE BEACH. Eleva., 18.35 ft.
tion of underground mark 13.98.
ne monument on the east side of Ocean Avenue about 20 paces
f and at right angles to the south curb line prolonged, of Wash-
Avenue, and about 30 paces east of the west curb line of Ocean
as it is put down in front of Life Saving Station No. 8 (old
). The bearing from the stone to the nearest corner of the
which is now on the northwest corner of Washington and Ocean
s, is about 20° northwest and the distance about 60 paces. The
nt projects a little above the surrounding surface. The bench
known as No. 4, as recorded in N. J. Geological Survey Report

TENNENT. **Eleva., 7**

A cross on the level of the girder seat and on the outer (the northerly end of easterly concrete abutment of P. R. R. bri Wemrock Brook, about three-quarters mile northwest of the stat: cross is fifteen and one-half feet from the bridge railing.

TENNENT. **Eleva., 9**

A cross on the easterly end of cement door sill of entrance t(room on the southwest face of the railroad station.

TENNENT. **Eleva.. 8**

A cross on the outer corner at the northeast end of cement of double door entrance, on the westerly face of factory of the Products Company, on the southeast side of, and back 150 f Main Street, 325 yards northeast of the railroad station.

TENNENT. **Eleva.. 12**

A cross on the level of the girder seat and on the southwe: of a large stone on the south end of east abutment of railroa over a highway, about one mile east of the station.

TENNENT. **Eleva., 14**

A cross on the level of the girder seat and on the southwest a large stone at the south end of east abutment of railroad bri highway, about one and three-quarter miles east of the stati bridge is about 100 feet southerly from the Freehold-Tennent hi

WATER WITCH. U. S. C. S. -14. **Eleva.,**

A red metal disc in the concrete base of a signal pole about west of the railroad station. The signal pole is north of the track and close to the rip-rap sea wall.

WEST END. (HOLLYWOOD.) **Eleva., 2**

A cross on the southeast corner of the stone on which the n of east girder rests at the east end of north abutment of railro: over a roadway near Lake Takanassee, about one-quarter mile the West End-Hollywood station.

WEST END. (HOLLYWOOD.) **Eleva., 1**

Elevation of underground mark 7.57 feet.

A stone monument on the lot of the Life Saving Station N number), 10 feet measured perpendicularly from the middle of end of old station building, which is along the lake and south of station. The line of face of north abutment of the new Ocea

WICKATUNK. **Eleva., 147.83 ft.**
Bottom of water table at the northeast corner of William Smock's residence, west of the track, directly opposite the railroad station.

WICKATUNK. **Eleva., 159.52 ft.**
A cross on the southeast corner of a red brick on the southeast corner, at the south end of west pier supporting frame of overhead highway bridge over the railroad, just south of the station.

YELLOW BROOK. **Eleva., 82.10 ft.**
A cross on the southeast corner of fourth stone step from the girder seat at the southerly end of westerly abutment of P. R. R. bridge over stream about one-half mile westerly from the station.

YELLOW BROOK. **Eleva., 88.46 ft.**
A cross on the northwest corner of concrete base of bell signal on the southerly side of the railroad track at crossing, by the station.

YELLOW BROOK. **Eleva., 88.89 ft.**
An iron hub at the center point between the rails and marking the P. C. of a curve to the right, at mile post 10-23, just east of the station. There is a large cross in the top of the iron post.

SECONDARY BENCH MARKS.[1]

ALLAIRE. **68.8 ft.**
Northeast rail of crossing about 0.3 mile northwest of station.

ALLAIRE. **52.4 ft.**
Southwest rail of crossing at the station.

ALLENWOOD. **64.8 ft.**
South rail of crossing easterly from station.

AVON-BY-THE-SEA. **12.4 ft.**
Rail at station.

BRADEVELT. **145.7 ft.**
Rail at station.

CREAM RIDGE. **117.0 ft.**
East rail of crossing at the station.

CREAM RIDGE. **135.12 ft.**
On the outer corner at the north end of wooden sill of entrance to church.

CREAM RIDGE. **109.1 ft.**
East rail of crossing one mile southeast of the station.

DAVIS. **121.1 ft.**
East rail of crossing at the station.

DAVIS. **121.4 ft.**
Point of frog of siding to creamery 200 feet southerly from the railroad station. The frog is the most northerly of two frogs close together.

EAST FREEHOLD. **175.5 ft.**
Rail of crossing at the station.

ENGLISHTOWN. **79.3 ft.**
Northerly rail of crossing at the station.

FAIRFIELD. **118.1 ft.**
Northeast rail of crossing at the station.

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[1] "Rail at station" means rail joint nearest the center of the station. "Rail at crossing" means rail joint; if no joint is at the crossing, the elevation is taken in the center of the road way. The elevations are given to the nearest tenth of a foot, except where otherwise noted.

FARMINGDALE.
Southeast frog of crossing of the two railroads at the statio

FRENEAU.
South rail of crossing at the station.

HORNERSTOWN.
Bottom edge of baseboard (top of foundation) at the northw
of the church on the Cream Ridge road.

HORNERSTOWN.
A cross on the outer corner at the easterly end of cement p
of a small one-story building on the southerly side of the high
250 feet east of the railroad station.

HORNERSTOWN.
Easterly rail of crossing at the station.

HORNERSTOWN.
Point of frog of siding 250 feet southerly from the station.

HOWELL.
Southerly rail of crossing at the station.

JONES SIDING. (FREEHOLD)
Southerly rail of crossing southeast of mile post 19.

LOW MOOR.
Rail at station.

MATAWAN.
Northeast frog of crossing of the Long Branch R. R. and the
branch.

MORGANVILLE. 1
Rail at station.

NELSONVILLE. (IMLAYSTOWN STATION.) 1
East rail of main track of crossing at the station.

NORMANDIE.
Rail at station.

SPRING LAKE BEACH.
Rail at station.

TENNENT.
Northeast rail of crossing at the station.

WICKATUNK. 1

LEY. **Eleva., 633.85 ft.**
oss 4.3 feet from the face of the building on the southwest corner ent slab at entrance to waiting room on the southerly face of the d station.

EY. **Eleva., 642.99 ft.**
of marble date (1913) stone set in the cobblestone foundation at theast corner of the Presbyterian chapel—300 yards north of the station on the west side of the road leading to Mount Olive. also the elevation of the foundation of the structure.

INGDALE. **Eleva., 256.21 ft.**
ss on the south end of the east abutment of a steel highway bridge quannock River near Bloomingdale station of the New York, Susa, and Western Railroad. The cross is on a projection westward e seat of truss near the angle formed by the wing wall and the t 3.6 feet below the level of the bridge floor, and about one foot the truss.

ON. **Eleva., 494.15 ft.**
ss cut on the east end of the north concrete parapet, under iron e foot west of west end of wing wall of Pond bridge, which carries reet over Rockaway River above the falls.

ON. **Eleva., 412.94 ft.**
ss cut in the east corner of the coping stone, level with the rail- the north corner of the Delaware, Lackawanna and Western l bridge over Rockaway River.

ON. **Eleva., 485.73 ft.**
ss on the southwest corner of the third stone of the shaft founda- the soldiers' monument on Main Street. The point is at the top urved edge and two inches below the base of the shaft.

ON. **Eleva., 494.77 ft.**
ss cut in the east end of the granite sill of the east door of the Engine House, 713 Main Street.

R. **Eleva., 315.22 ft.**
ss on the center of the north end of the concrete pier of the New squehanna and Western Railroad bridge over Stone House Brook, station. The cross is 9.8 feet north of the north rail, and 4.3 er.

R. **Eleva., 333.30 ft.**
ss on the south end at the outer edge of the door sill at the en- o the First National Bank on Boonton Avenue.

R. **Eleva., 342.40 ft.**
ss on the outer edge at the north end of the east abutment of the rk, Susquehanna and Western Railroad bridge over Pequannock bout 1,000 feet west of the station. The cross is at the angle, by a bevel in the seat for the east end of the truss, 5.7 feet lower rail.

Eleva., 691.28 ft.
e concrete cap directly over the date "1908" at the southerly end abutment of Central Railroad bridge over stream about one-half sterly from the station.

Eleva., 718.50 ft.
ss on the bridge seat directly over the date "1905" and six and feet from the girder on the north end of the west abutment of Railroad bridge over a brook about one-third mile easterly from on.

CEDAR KNOLLS. (MONROE STATION.) **Eleva.,**
A cross about 50 feet north of the north rail of main tr
center of the north concrete parapet of small culvert under t
town and Erie Railroad about one-quarter mile northeast
station. A railroad siding leaves the main track at this poin

CHATHAM. **Eleva.,**
A cross cut in the sixth coping stone from the north end, in
of the east parapet of the Delaware, Lackawanna and Wester
bridge over Passaic River. This coping stone is six feet lon
feet wide. The cross is 26.1 feet from the north end and 45.6
the south end of the east parapet.

CHATHAM. **Eleva.,**
A cross cut in the west end of the sill (2 inches from the
and one-half inches from the brick wall and 10 inches fron
saddle) at the entrance to the Mayor's Office and Library a
end of the Town Hall, which stands on the north side of
Avenue between the Delaware, Lackawanna and Western Ra
Main Street.

CHATHAM. **Eleva.,**
A cross cut in the stone parapet on the east side of the st
to the front entrance of the public-school building, which sta
north side of Fairmount Avenue just west of the Delaware, L
and Western Railroad. The parapet measures four feet by 2.
cross is 0.7 foot from the side of the building, 3.3 feet from
the parapet and two feet from the pilaster just east of the ent

CHATHAM. **Eleva.,**
A cross cut in the north post of the west wall of an arch br
carries Main Street over a small stream at the junction of Main
ette Streets.

CRESTMOOR. **Eleva.,**
A cross on the outer corner of the lowest stone step at th
of north stone abutment of Central Railroad bridge over a bro
mile south of the station.

CRESTMOOR. **Eleva.,**
A cross on the outer corner of bridge seat, three feet from
on the south end of west abutment of highway bridge over So
of Raritan River, just west of the railroad track, one-half mi
the station.

ILLE. Eleva., 515.40 ft.
ss cut in the bluestone sill of the basement window in the front or
the building in the ell to the north of the main entrance to the
chool.

. Eleva., 558.64 ft.
s in the surface (15 inches south of the northwest corner) of the
crete sidewalk of the bridge carrying Mercer Street over Rocka-
er. This cross is three inches east of the west parapet of the

Eleva., 572.99 ft.
s cut in the water table at the southeast corner of George Rich-
ck building at the northwest corner of Blackwell and Sussex

Eleva., 582.08 ft.
s cut in the top and in the northeast corner of the bluestone
the west side of the bottom step of the main front entrance to
orial Presbyterian Church. This mark is close to the base of the
ower.

Eleva., 571.09 ft.
s cut in the top of the granite stone at the top of the wing wall
orthwest corner of the bridge which carries Sussex Street over
y River.

Eleva., 574.02 ft.
s cut in the southeast corner of the brownstone sill of the east
to the High School which stands on the corner of McFarland
sex Streets.

Eleva., 537.81 ft.
s cut in the outside corner on top of the granite stone forming
h end of the west bridge seat of the girder bridge which carries
rnia Mine Railroad over Rockaway River.

ERS. Eleva., 677.94 ft.
s. 2.4 feet below the rail, on a large stone at the south end of
tment of Central Railroad bridge over a brook about one-quarter
t of the station. This is the most westerly of two bridges close

ERS. Eleva., 681.94 ft.
s. 2.6 feet below the rail, on the outer corner of stone at the
end of west abutment of Central Railroad bridge about 400
st of the station and adjacent to a private crossing.

ERS. Eleva., 679.41 ft.
s three feet measured in a southerly direction from the center
ch on the highest point of a large stone on the westerly coping
ay culvert over the mill race 100 yards south of the railroad at
tion of the Succasunna-Bartley road.

ERS. Eleva., 684.27 ft.
s 10.5 feet from the girder on the northwest corner of the bridge
the north end of east abutment of the second railroad bridge
0 feet east of the station.

ERS. Eleva., 726.85 ft.
s near the northeast corner of a large stone at the old Nicholas
w used as a private garage) about one-half mile northerly from
oad station on the easterly side of the Netcong and Budd Lake
A private road runs east at this point.

FOUR BRIDGES. **Eleva.,**
A cross eight feet from the stop logs and 2.0 feet above t
the dam on the west end of the southerly concrete wall at
gates of mill pond near the railroad crossing. The gate is ab
southerly from the mill.

FOUR BRIDGES. **Eleva.,**
A cross on the outer corner of large stone forming the
from the bottom of the wing wall at the south end of westerl
of Central Railroad bridge over stream about 300 yards ea
the highway crossing.

GILLETTE. **Eleva.,**
A cross on the east end of the north wall of the small pipe cu
the railroad, about 300 yards west of the station.

HANOVER. (STATION) **Eleva.,**
A cross 16 feet from the rail in the center and on the sc
concrete culvert under the Morristown and Erie Railroad
highway crossing, three-tenths of a mile west of the station.

HANOVER. (STATION) **Eleva.,**
A cross on the cement platform immediately below the nort
of the Morristown and Erie Railroad station.

HANOVER. (STATION) **Eleva.,**
A cross 1.2 feet below the rail and five feet away on the no
of east concrete abutment of Morristown and Erie Railroad
a highway eight-tenths of a mile east of the station.

HOPATCONG JUNCTION. **Eleva.,**
A cross on the northeast corner of large stone on which rest
end of east truss of steel bridge carrying the Central Railro
Morris Canal just north of the station.

KENVIL. **Eleva.,**
A cross 13 feet from the rail on the southeast corner of th
step from the top at the easterly end of south wall of culver
Central Railroad, 250 yards westerly from the station.

KENVIL. **Eleva.,**
A square cut on the northeast corner and at the east e
wing wall of east abutment of highway bridge over the Morris
the Central Railroad station.

KENVIL. **Eleva.,**

E JUNCTION. **Eleva., 711.98 ft.**

ross cut in the top and in the southwest corner of the south concrete et of the four-track bridge which carries the Delaware, Lackawanna Vestern Railroad over the Lake Hopatcong Branch of the Central ad of New Jersey, one and three-quarter miles west of Wharton 1.

ING. **Eleva., 933.50 ft.**

oss cut in the northeast corner of the bluestone sill of the front ce of the block-house office building of W. E. King, on the south the Landing road.

ING. **Eleva., 936.55 ft.**

oss in the west end of the south concrete parapet of the concrete which carries the highway over the Delaware, Lackawanna and n Railroad and Morris Canal, about 100 feet west of Hopatcong . The bench mark is above the west springing line of the arch and et higher and at the east end of the concrete guard.

NG. **Eleva., 939.67 ft.**

ss cut in the southwest corner of the concrete sill of the west main e to the Lake Hopatcong station of the Delaware, Lackawanna and n Railroad, on the west side of tracks. The bench mark is one ove the road level.

EWOOD. **Eleva., 728.83 ft.**

nost point of flange of the most westerly iron post of two posts concrete on the southerly side of the tracks 250 feet northeast of ntral Railroad station.

LN PARK. **Eleva., 182.48 ft.**

ss cut in the southwest corner of the stone forming the upper step east end of the north wall of Morris Canal lock No. 12, east.

LN PARK. **Eleva., 184.13 ft.**

oss cut in the south end of the bluestone door sill of the entrance public schoolhouse on the back river road to Two Bridges.

LN PARK. **Eleva., 178.00 ft.**

ss cut in the south concrete platform of the Delaware, Lackawanna estern Railroad station. The point is in close to the building at ddle of the south side below the window.

LN PARK. **179.17 ft.**

oss cut in the north side of the foundation (directly over the "9" 6") of the water tower, 900 feet west of the Delaware, Lacka- and Western Railroad station.

VALLEY. (GERMAN VALLEY) **Eleva., 536.47 ft.**

oss 2.2 feet below the rail near the outer corner at the north end terly abutment of small steel girder bridge carrying the Central d over a brook about three-quarters mile southwest of the station. is a farm road adjacent to the bridge.

VALLEY. **Eleva., 535.58 ft.**

oss directly over the center of the opening on the south parapet nall concrete culvert under the Central Railroad about 175 yards the station.

VALLEY. **Eleva., 531.52 ft.**

ss on the outer corner at the south end of door sill of main en- to the Evangelical Lutheran Zion Church on the west side of the reet between the station and the river.

VALLEY. **Eleva., 532.86 ft.**

ss on the southeast corner of stone at the east end of north abut- arch highway bridge over South Branch of Raritan River. The the support for the end iron post of railing of the sidewalk.

MOUNT ARLINGTON. **Eleva., 782.84 ft.**

A cross cut in the southeast corner of the south concrete parapet of t bridge which carries the Delaware Lackawanna and Western Railro over the Kenville-Mt. Arlington road. The bridge is 600 feet west of th station.

MOUNT TABOR. **Eleva., 502.06 ft.**

A cross cut in the northwest corner of the coping of the wall over the north end of a culvert, under the Morris and Essex Railroad, for carrying off the overflow of a pond, one mile east of Mount Tabor.

NAUGHRIGHT. **Eleva., 560.07 ft.**

A cross four feet north of the girder on the northeast corner of ston at the north end of the pier of Central Railroad bridge over Stony Broo about one-quarter mile west of the station.

NAUGHRIGHT. **Eleva., 560.42 ft.**

A cross on the outer corner at the easterly end of north stone abutmen of steel highway bridge over South Branch of Raritan River about 0. mile southerly from the railroad track.

NAUGHRIGHT. **Eleva., 574.33 ft.**

A cross nine feet from the girder on the outer corner of the bridge sea at the south end of westerly stone abutment of Central Railroad bridg over South Branch of Raritan River about one-half mile northeast of th station.

NETCONG. **Eleva., 874.13 ft**

A cross cut in the northeast corner of the bluestone sill of the entranc at the east end of Stanhope-Netcong station of the Delaware, Lackawann and Western Railroad.

NEW FOUNDLAND. **Eleva., 764.41 ft.**

A cross at the outer edge of the west end of the bluestone window sil of the Standard Oil Co. pumping station. The building is about 100 fee south of the New York, Susquehanna and Western Railroad tracks, an about 1,000 feet east of the station. The cross is 3.5 feet above the groun and four feet from the northwest corner of the building on the nort face.

NEW FOUNDLAND. **778.58 ft**

A cross on the concrete base of the southwest column supporting th water tower at the station. The cross is 1.4 feet above the ground o the southeast corner of the base. It is 14.7 feet north of the north rai of the railroad.

MORRIS. **Eleva., 890.18 ft.**
ıss cut in the south end of the bluestone sill of the south base- :ndow on the east side of the public schoolhouse.

:VILLE. **Eleva., 494.31 ft.**
ss cut in the west end of the bluestone door sill of the north ' to the concrete engine house, of Field, White & Company's paper

VILLE. **Eleva., 495.53 ft.**
ıs cut in the south end (at the end of two trusses) of the blue- p of the center pier supporting the two spans of the highway ver the Rockaway River, at the paper mills.

NAY. **523.18 ft.**
ench mark is on the northeast corner of the flange of the cast- :plate at the northeast corner of the iron bridge over the Morris : the foot of the plane.

NAY. **Eleva., 527.50 ft.**
s cut in the outside corner of the north end of the west abutment :ain Street bridge over the Rockaway River.

NAY. **Eleva., 533.63 ft**
ss cut in the east end of a bluestone door sill of the easterly reet entrance to the municipal building.

NAY. **563.87 ft.**
ench mark is a point taken on the northeast corner of the flat of the top of the bluestone sill of the east front window of Strait's Main Street. The bench mark is indicated by an arrow cut in ing about four inches below the point.

NPORT. **Eleva., 873.54 ft.**
ottom of a square hole cut in the west end of the bridge seat of ı concrete abutment of the four track Delaware, Lackawanna and Railroad bridge over Morris Canal.

NPORT. **Eleva., 874.78 ft.**
s cut in the southeast corner of the wrought iron bedplate of the d of the east girder of the four track Delaware, Lackawanna and Railroad bridge over the highway.

NPORT. **Eleva., 864.57 ft.**
:s cut in the southeast corner of the east coping stone of the ing wall of the overflow on the east side of the Morris Canal, a :tance north of the Delaware, Lackawanna and Western Railroad.

IG. **Eleva., 224.88 ft.**
ss on the outer edge at the north end of the window sill, first the office door of the silk factory of Schwarzenbach, Huber Co. rance faces the railroad, and is about 800 feet north of the The cross is 5.5 feet above the ground.

IG. **Eleva., 259.73 ft.**
:s on the outer edge at the west end of the sill of a basement at northern face of public school. The cross is about one foot e ground, and six feet east of the west face of the building.

:UNNA. **Eleva., 731.37 ft.**
ıt 1.8 feet out from the door on the level of the cement sill at hwest corner of stone projection on the northerly side of main to the High School, a red brick structure on the easterly side of Avenue.

O. **Eleva., 226.56 ft**
s cut in the west end of the door sill of the entrance near the and on the south side of the Delaware, Lackawanna and Western station.

TOWACO. **Eleva., 243.39 ft.**

A cross cut in the top of a brownstone block which forms the northeast corner of the foundation of the Methodist Episcopal Church, which stands near the tracks and about 1,000 feet east of the Delaware, Lackawanna and Western Railroad station.

TOWACO. **Eleva.. 224.11 ft.**

A cross cut in the west abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over the highway west of the station. The point is on the concrete bridge seat, four feet below the track level, and three feet north of the north rail.

TOWACO. **Eleva., 194.46 ft.**

A cross cut in the northwest corner of the bridge seat of the west concrete topped abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over a road at the foot of plane No. 10 east. This point is one foot south of the north end of the abutment, three feet below, and 25 feet north of the north rail of the two-track line.

WHARTON. **Eleva., 612.60 ft.**

A cross cut in the outside corner of the upper step at the north end of the western abutment of the Delaware, Lackawanna and Western Railroad bridge over the Rockaway River, three-quarters of a mile southeast of Wharton.

WHARTON. **Eleva., 602.35 ft.**

A cross cut in the outside corner of the lowest step at the south end of the western abutment of the bridge which carries the High Bridge Branch of the Central Railroad of New Jersey over Rockaway River, three-quarters of a mile southeast of Wharton.

WHARTON. **Eleva., 666.25 ft.**

A cross cut in the west end of the south abutment of the bridge which carries the High Bridge Branch of the Central Railroad of New Jersey over the Delaware, Lackawanna and Western Railroad. This cross is cut on the granite stone at the end of the bridge seat.

WHARTON. **Eleva., 694.96 ft.**

A cross cut in the top of and in the south end of the bluestone sill of the Main Street entrance of Wharton Public School.

WHIPPANY. **Eleva., 222.63 ft.**

Top of southerly bolt at the southeast edge of the bedplate of the southeast column of steel frame supporting water tank at Eden Mill.

WHIPPANY. **Eleva., 202.60 ft.**

A cross 1.7 feet below and 4.8 feet from the rail on the north end of east concrete abutment of Morristown and Erie Railroad bridge over the

SECONDARY BENCH MARKS.[1]

LEY. 608.1 ft.
therly rail of crossing one-half mile southwest of station.

LEY. 633.4 ft.
at station.

.EY. 632.1 ft.
m edge of siding (top of foundation) at the southwest corner of artley Co.'s building on the north side of the tracks at the railation.

EY. 642.97 ft.
nt floor of porch at the southeast corner of the Presbyterian

EY. 645.8 ft.
erly rail of crossing one mile northeast of station.

INGDALE. 259.5 ft.
t station.

718.6 ft.
erly rail of crossing at station.

KNOLLS. (MONROE STATION.) 263.8 ft.
erly rail of crossing at station.

KNOLLS. (MONROE STATION.) 307.6 ft.
erly rail of M. and E. Railroad at crossing, one mile southwest of near the Morristown sewerage disposal plant.

MOOR. 492.9 ft.
rail of crossing one-half mile south of station.

MOOR. 495.34 ft.
ss on the concrete base of "Private Crossing" sign west of the t the station.

MOOR. 494.9 ft.
rail of crossing at station.

ERS. 688.0 ft.
rail of crossing just east of the station.

ERS. 688.6 ft.
rail of crossing 165 yards west of the station.

BRIDGES. 584.2 ft.
rail of crossing near the mill.

TE. 216.7 ft.
at station.

ER. (STATION) 179.6 ft.
rail at the east end of M. and E. Railroad bridge over Whippany 0.8 mile west of the station.

ER. (STATION) 198.6 ft.
rail of diagonal crossing 0.3 mile west of the M. and E. Railroad

ER. (STATION) 225.2 ft.
rail of crossing at the station.

L. 725.5 ft.
rail of Central Railroad crossing southerly from the station.

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at station" means rail joint nearest the center of the station. "Rail ng" means rail joint; if no joint is at the crossing, the elevation is taken enter of the roadway. The elevations are given to the nearest tenth of xcept where otherwise noted.

KENVIL. 717.0 ft.
Southeast frog of crossing of N. J. Central and D., L. and W. railroad northeast of the station.

KENVIL. 721.1 ft.
North rail of Central Railroad at crossing one mile northeast of station.

LEDGEWOOD. 727.3 ft.
Northerly rail of Central Railroad crossing at the station.

LEDGEWOOD. 727.18 ft.
A cross on the concrete base of warning sign east of the highway and 12 feet southerly from the track at the Central Railroad station.

LONG VALLEY. 542.7 ft.
North rail of main track at crossing just west of station.

MIDDLE VALLEY. 507.4 ft.
North rail of main track at crossing just west of the station.

MILLINGTON. 277.1 ft.
Rail at station.

MONROE. (See CEDAR KNOLLS.)

NAUGHRIGHT. 574.9 ft.
North rail of crossing at the station.

NEWFOUNDLAND. 775.2 ft.
Rail at crossing east of station.

NEWFOUNDLAND. 777.1 ft.
Rail at station.

POMPTON PLAINS. 192.6 ft.
Rail of crossing at station.

STIRLING. 227.0 ft.
Rail of crossing at the station.

WHIPPANY. 204.3 ft.
North rail of crossing about 150 yards west of the station.

OCEAN COUNTY.[1]

NEW EGYPT. Eleva., 72.96 ft.
A cross on the center of the concrete wall on the north side of the turntable pit northeast of the station and 25 feet south of the main track.

EGYPT. **Eleva., 89.11 ft.**
ross on the northeast corner of the southwest concrete pier of city tower on the south side of the Cookstown road at the west edge of wn.

EGYPT. **Eleva., 80.70 ft.**
ross on the outer corner at the south end of bluestone door sill of entrance to the M. E. Church on the corner of Fort Avenue and the ood road.

EGYPT. **Eleva., 89.00 ft.**
oss next to door jamb on the west end of cement door sill of the asterly entrance on the south face of New Egypt Creamery on the side of the tracks about 0.4 miles west of the station. This is also vation of the floor.

ERTON. **Eleva., 22.632 ft.**
ation of underground mark, 17.972 feet.
monument (No. 8) is set in the northwest corner of the Presby- churchyard at the corner of Main and Marine streets, three feet the east line of Marine Street, and 32.9 feet from the northwest of the church. It is due south from two stones on the lawn of rice, the three stones thereby establishing a true meridian.

PASSAIC COUNTY.[1]

INGDALE. **(See Morris County.)**

.OTTESBURG. **Eleva., 682.44 ft.**
ss on the southeast corner of the second step from the top at the d of the north abutment of the bridge, which carries the New York. hanna and Western Railroad over Pequannock River, about one- mile north of the station.

.OTTESBURG. **Eleva., 737.21 ft.**
ss on the northeast corner of the southeasterly concrete pier, which ts the steel column of the highway bridge over the New York, Susna and Western Railroad about 800 feet west of the station.

ON. (ATHENIA.) **Eleva., 183.78 ft.**
oss on top of bluestone coping on the northeast corner of the st wing wall of the bridge on Stone House Plains Road, over the Canal.

ON. (ATHENIA.) **Eleva., 179.50 ft.**
bench mark is on a small cut in a projecting stone, 4.6 feet above ound, at the west end of the north abutment of the road bridge h Avenue over the Morris Canal, one mile southwest of Athenia. int is indicated by an arrow head.

ON. (ATHENIA.) **Eleva., 164.80 ft.**
ss cut in the southeast corner of the west end of the culvert which High Avenue over a small stream, about 800 feet northeast from rris Canal.

ON. (RICHFIELD.) **Eleva., 183.11 ft.**
ss cut in the east end of the bluestone sill of the window, between stone marked "1907," and the main entrance to St. John's German n Church, on Clifton Avenue.

ON. (RICHFIELD.) **Eleva., 186.72 ft.**
bench mark is the bottom edge of the corner stone, marked "1907," ohn's German Lutheran Church.

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[1] des all previous lists.

CLIFTON. (RICHFIELD.) **Eleva., 191.84 ft.**
A cross cut in the east end of the bluestone sill of the front basement window, nearest the east side of Public School No. 2, Clifton Avenue.

GREAT NOTCH. **Eleva., 313.41 ft.**
A cross on the northwest corner of stone pier supporting the westernmost column of southerly steel frame of overhead highway bridge at the Erie Railroad station.

GREAT NOTCH. **Eleva., 313.32 ft.**
A cross on the cement platform near the southwest corner of the Erie Railroad station, on the north side of the tracks.

GREAT NOTCH. **Eleva., 322.26 ft.**
A cross on the southwest corner of the most westerly pier of four center piers supporting the steel columns of a water tank on the north side of the Erie Railroad tracks at the station.

GREAT NOTCH. **Eleva., 330.32 ft.**
A cross near the south edge of the bridge seat 3.5 feet from the west end of north abutment of overhead highway bridge just west of the Erie Railroad station.

GREAT NOTCH. **Eleva., 334.88 ft.**
A cross 10 feet from the girder on the outer corner of bridge seat at the west end of south abutment of Erie Railroad bridge over highway about one-half mile southeast of the station.

HAWTHORNE. **Eleva., 41.83 ft.**
A cross cut in the top of the granite coping (six inches back from the southeast corner) of the east wing wall of the north abutment of the bridge which carries the Erie Railroad over the Passaic River. The point is five feet below the track level.

LITTLE FALLS. **Eleva., 200.13 ft.**
On the outer corner at the northerly end of cement door sill of center entrance on Stevens Avenue to the Municipal Building at Warren Street.

LITTLE FALLS. **Eleva., 203.28 ft.**
On the outer corner at the easterly end of door sill of Warren Street entrance to the Public Library at Stevens Avenue.

LITTLE FALLS. **Eleva., 174.67 ft.**
A cross cut in the stone coping at the end of the iron railing on the west side of the Passaic River, of the Morris Canal aqueduct.

NTAIN VIEW. **Eleva., 180.65 ft.**
ross cut in the east end of the concrete door sill of the south en- of the Delaware, Lackawanna and Western Railroad station.

FOUNDLAND. **(See Morris County.)**

IDGE. **Eleva., 899.61 ft.**
oss on the concrete seat at the east end of the south girder 0.6 m the corner, and 2.7 feet south of the girder of the bridge which the highway over the New York, Susquehanna and Western d, about one mile northwest of the station.

C. **Eleva., 56.69 ft.**
ss cut in the south end of door sill of the front entrance of the Trust and Safe Deposit Company's building, which stands on the le of Main Street between Academy and Bloomfield avenues.

C. **Eleva., 60.31 ft.**
ss cut in a raised projection, in front of the wall, on the extreme d of the door sill of the entrance to the municipal building stand- he northwest corner of Howe Avenue and Prospect Street. This is between two fire engine rooms.

C. **Eleva., 26.51 ft.**
ss cut in the extreme southwest corner of the west end of the f the north wall of the arch bridge which carries Passaic Avenue tailrace from the mills. This bridge is a short distance west of York, Susquehanna and Western Railroad.

SON. **Eleva., 99.45 ft.**
ss cut in the south end of the Main Street entrance to St. Boniface at the southeast corner of Main and Slater Streets.

SON. **Eleva., 80.12 ft.**
ss cut in the east end of the door sill of the main front entrance arket Street M. E. Church.

SON. **Eleva., 88.82 ft.**
ss cut in the west end of the door sill of the main entrance to the al building on the corner of Market and Union Streets.

SON. **Eleva., 99.15 ft.**
ss cut in the north end of the door sill of the main entrance to the esbyterian Church, on the corner of Main and Ward Streets.

SON. **Eleva., 103.18 ft.**
ss cut in the top of the second cheek stone from the bottom, at thwest corner of the base of the second pillar from the north he Hamilton Street entrance to the Passaic County Court House.

SON. **Eleva., 181.24 ft.**
point is on the East Jersey Water Company's bench mark at Stony servoir, Grand Street and Reservoir Avenue, and is a cross cut op rock, one foot north of the concrete wall on the Grand Street d 36 feet east of the middle of the intake pipes near the corner treets.

SON. **Eleva., 187.69 ft.**
ss cut in the north corner of the concrete facing the east abut- the Delaware, Lackawanna and Western Railroad bridge, over River, known as High Bridge. This bridge is between Paterson tle Falls.

ON. **Eleva., 207.09 ft.**
ss on the outer edge at the west end of the brownstone door sill iddle entrance to the Pompton Reformed Church.

POMPTON JUNCTION. Eleva., 217.26 f

Northeast frog point at the crossing of New York, Susquehanna Western, and New York and Greenwood Lake Railroads.

POMPTON JUNCTION. Eleva., 235.76 ft.

A cross on the northwest corner of the stone on which rests the end of the north truss at the north end of the east abutment of New Yor Susquehanna and Western Railroad bridge, over Pequannock River, abo three-quarters of a mile west of the station. The cross is six feet nort of the north rail, and 5.2 feet below.

POMPTON LAKES Eleva., 203.18 ft.

A cross about six inches diagonally from the southwest corner of th seat of the steel truss at the south end of the eastern concrete abutme of the highway bridge over Wanaque River northwest of the station.

POMPTON LAKES. Eleva., 204.00 ft.

A cross on a large stone on the north end of the west abutment at th angle of the wing wall of the New York, Susquehanna and Western Rai road bridge over Wanaque River, west of the station. The cross is on th east corner of the stone, 5.3 feet lower than the rail.

RICHFIELD. (See Clifton.)

SMITH MILLS. Eleva., 425.16 ft.

A cross on the high point of the large boulder near the north end west abutment of the steel highway bridge over Pequannock River. Th cross is 1.7 feet diagonally from the corner of the abutment, 5.2 fe below the bottom plate of girder, and four feet north of the center o north girder.

•TOTOWA. (See Little Falls Station.)

WAYNE. Eleva., 172.70 ft.

Top of the rail of New York and Greenwood Lake Railroad at statio

WAYNE. Eleva., 175.63 ft.

A cross on the east end of the south abutment of New York and Gree wood Lake Railroad bridge over Pompton River, about one mile north o Wayne station. The cross is six inches diagonally from the northea corner of girder seat, 4.7 feet east of east girder, and 5 feet lower tha the rail.

SECONDARY BENCH MARKS.

AY. **Eleva., 16.81 ft.**
r bolt in monument at the northwest corner of the railroad ›latform.

AY. **Eleva., 16.08 ft.**
s on the southwest corner of concrete wall at the southwest the mill at the railroad station.

AY. **Eleva., 43.15 ft.**
on the outer corner at the east end of granite door sill of front to the Baptist Church, a red-brick structure on the street leading n and southwest of the railroad station.

Y JUNCTION. **Eleva., 24.08 ft.**
bolt in monument at the southwest corner of the railroad atform.

WN. **Eleva., 136.42 ft.**
ge and corner of marble stone set in the foundation at the southier of the Baptist church. (The elevation is the same as the lge of base board of building.)

WN. **Eleva., 127.58 ft.**
nch mark is a cross cut on north end of stone door sill of front of Daretown Presbyterian Church.

WN. **Eleva., 128.31 ft.**
bolt in monument at the southwest corner of the railroad

WN. **Eleva., 120.86 ft.**
immediately below the southeast corner of brickwork on condation of chimney of creamery on the southerly side of the west of the station.

Eleva., 106.18 ft.
on the outer corner of bridge seat at the east end of southerly of railroad bridge over stream, about three-quarters mile from the station. The bridge is the most northerly of two lose together.

Eleva., 113.02 ft.
bolt in monument on the west side of the track about 25 yards from the railroad station.

Eleva., 118.11 ft.
outer corner at the southerly end of window sill of large window ain Street face of the postoffice, a small stone structure between and the railroad station.

Eleva., 118.33 ft.
on the outer corner at the northerly end of door sill of Main trance to the First National Bank near the railroad station.

Eleva., 121.16 ft.
on the outer corner at the easterly end of door sill of entrance rthwest corner of the M. E. Church on Main Street, one block from the station.

Eleva., 116.22 ft.
on the outer corner at the south end of cement door sill of at the southeast corner of school building on the westerly side Street southerly from the railroad station.

VILLE. **Eleva., 133.57 ft.**
on the southeast corner of concrete base of second signal, 150 therly from the station and west of the track.

MONROEVILLE. **Eleva., 135.03 ft.**
A cross on the southwest corner of concrete block immediately in fro of the center of the railroad station and on the west side of the track.

NEWKIRK. **Eleva., 134.08 ft.**
On the outer corner at the west end of top cement step of several ste leading to porch of farm house on the north side of the highway an north of the railroad station.

NEWKIRK. **Eleva., 125.03 ft.**
A cross on the outer corner of bridge seat at the south end of eac concrete abutment of railroad bridge over highway about one-quarter mil west of the station.

PALATINE. **Eleva., 95.96 ft.**
A cross on the outer corner of bridge seat at the west end of southerl concrete abutment of railroad bridge over stream, about 0.6 mile north east of the station.

PALATINE. **Eleva., 110.25 ft.**
A cross on the southeast corner of concrete wall around well and pum opposite the railroad station.

PEDRICKTOWN. **Eleva., 6.83 ft.**
A cross on the southeast corner of concrete base of signal on the sout side of the railroad track easterly from the station.

PEDRICKTOWN. **Eleva., 18.84 ft.**
A cross on the outer corner at the west end of door sill of entrance t the First National Bank, a brick and stone structure at the cross roads.

PEDRICKTOWN. **Eleva., 11.92 ft.**
A cross on the outer corner at the northerly end of door sill of entranc on the west face and at the northwest corner of public school, a re brick and stone structure, 125 yards southerly from the crossroads.

PENNSGROVE. **Eleva., 16.87 ft.**
A cross cut in the top of the most northerly foundation bolt holdin steel standpipe to base at Friendship Station. The bolt is the one neare the highway.

PENNSGROVE. **Eleva., 16.02 ft.**
A cross on the outer corner at the northwest end of cement door si of entrance under the alcove and on the northeast face of the High Schoo on the corner of Harmony and North Broad Streets.

PENNSGROVE. **Eleva., 13.31 ft.**

TON. Eleva., 21.20 ft.
he outer corner at the north end of window sill of the most north-indow on the west face of filter house a small red-brick building e the pumping station of the Salem City Water Works.

'ON. Eleva., 11.43 ft.
er bolt in monument at the northeast corner of the railroad station.

'ON. Eleva., 4.70 ft.
ss cut on the most northerly point of the octagonal shaped steel n the north pier of highway bridge over Alloway Creek at the Glass Company's store.

ON. Eleva., 18.97 ft.
row cut at the bottom of the inscription and on the east end of ved on granite monument set by the Daughters of the American ion and located on the northerly side of Main Street, 100 yards from the Quinton Glass Company's Store.

. Eleva., 11.47 ft.
ss on the outer corner at the southerly end of marble door sill of oadway entrance to the Memorial Baptist Church at the corner th Street.

. Eleva., 16.82 ft.
ss near the outer edge, nine inches from the northwest end of door sill of Broadway entrance to the Salem County Court House et Street.

. Eleva., 15.39 ft.
s on the outer corner at the southerly end of door sill of Market ntrance to the City National Bank at the corner of Broadway and Street.

. Eleva., 13.87 ft.
ss on the outer corner at the southerly end of door sill of front to the First Presbyterian Church on Market Street.

. Eleva., 15.91 ft.
bench mark is a cross cut at the foot of fluted column, on south ntrance to surrogate's and clerk's office.

. Eleva., 14.67 ft.
bench mark is a cross cut on south side of granite door sill of trance of Episcopal Church, on Market Street.

. Eleva., 15.79 ft.
s on the outer corner at the westerly end of door sill of entrance ortheast face of the High School on New Market Street, one block Broadway.

TOWN. Eleva., 47.65 ft.
ench mark is cross cut on south end of marble door sill of front of brick Baptist Church, on Main Street.

TOWN. Eleva., 46.14 ft.
ench mark is a cross cut on north end of lowest stone step of trance of Woodstown Hotel.

TOWN. Eleva., 58.74 ft.
ench mark is a cross cut on southwest end of marble door sill d brick National Bank of Woodstown opposite the Friends Meeting n Main Street.

TOWN. Eleva., 48.57 ft.
outer corner at the northeast end of top step and sill of main to the First National Bank at the corner of East Avenue and eet.

WOODSTOWN. **Eleva., 62.3**
A cross on the outer corner at the north end of blue sandstone w sill of the most northerly basement window on the west face of the school, on the southerly side of East Avenue, east of the railroad st

WOODSTOWN. **Eleva., 66.8**
A cross cut in the top of the most easterly foundation bolt of standpipe of City water supply on the west side of the railroad no the station.

YORKTOWN. **Eleva., 109.9**
Copper bolt in monument at the westerly face of the railroad stati

YORKTOWN. **Eleva., 111.4**
A cross immediately below the corner of the building at the sout of cement floor of porch of Duffel's store on the west side of the hi at the railroad station.

SECONDARY BENCH MARKS.[1]

ALLOWAY. **16.**
Southeast rail of crossing at the station.

ALLOWAY. **19.**
Southeast rail of crossing 0.4 mile west of station.

ALLOWAY JUNCTION. **24.**
Point of frog of junction of Salem and Quinton branches of the &. S. Railroad, 100 yards northeast of the station.

ALLOWAY JUNCTION. **23.**
West rail of crossing one-half mile south of the station on the Q branch.

DARETOWN. **126.**
Southerly rail of crossing, one-quarter mile west of the station.

DARETOWN. **127.**
North rail of crossing at the station.

ELMER. **110.**
Southerly rail of crossing, one-quarter mile west of station on the branch.

ELMER. **124.**
Southerly rail of crossing, three-quarters mile west of station Salem branch.

CK. 57.3 ft.
rail of crossing, 0.6 mile southwest of the station.

EVILLE. 135.7 ft.
rail of crossing at the station.

EVILLE. 139.9 ft.
n edge of baseboard (top of brick foundation) at the northeast
f dwelling on the west side of the railroad and north of the
at the station.

EVILLE. 129.8 ft.
rail of double crossing, 0.3 southwest of the station.

EVILLE. 115.3 ft.
ail of crossing, one and one-quarter miles southwest of the station.

STATION. 29.9 ft.
ast rail of crossing.

RK. 134.0 ft.
rail of crossing, 0.3 mile east of station.

RK. 128.2 ft.
rail of crossing at the station.

N STATION. 14.4 ft.
rail of crossing.

INE. 109.6 ft.
rail of crossing at the station.

INE. 107.8 ft.
of frog of siding 70 yards southwest of station.

INE. 91.7 ft.
ail of crossing three-quarters mile southwest of the station.

ING. 111.8 ft.
erly rail of crossing at the station.

ING. 112.7 ft.
ss on the center of southeast concrete parapet of small highway
on the north side of the tracks at the station.

ING. 116.6 ft.
rail of crossing, 0.35 mile west of the station.

KTOWN. 3.8 ft.
rail of crossing at the station.

GROVE. 12.6 ft.
rail of crossing at Friendship Station.

GROVE. 6.0 ft.
erly rail of Main Street crossing of track leading to the station.

NTOWN STATION. 25.0 ft.
east rail of crossing.

AIRY STATION. 73.8 ft.
rail of crossing.

AIRY STATION. 73.2 ft.
ss on center of east parapet of small highway culvert at the station.

ON. 40.0 ft.
rail of crossing, one and one-half miles east of station.

ON. 7.5 ft.
rail of Main Street crossing near the bridge over Alloway Creek.

TON JUNCTION. 42.0 ft.
oot from the point of frog of the junction of the Elmer and Salem
s of the Penn Railroad.

WOODSTOWN. 47.6 ft.
Southeast rail of crossing at South Woodstown Station.

WOODSTOWN. 54.3 ft.
West rail of crossing at the station.

YORKTOWN. 109.5 ft.
North rail of crossing at the station.

SOMERSET COUNTY.[1]

BLAWENBURG. **Eleva., 157.40 ft.**
A cross on the center and at the angle of the north parapet of cast-iron culvert at the intersection of the Skillman and Hopewell roads in the village.

GLADSTONE. **Eleva., 234.74 ft.**
A cross on a projection of the stone base at the north end of a retaining wall along Peapack Brook and the easterly side of the Main Street about 165 yards north of the intersection of the road leading to Pottersville.

GRIGGSTOWN. **Eleva., 37.17 ft.**
A cross on the bridge seat at the northerly end of east stone abutment of small highway bridge over water course about 100 yards west of the canal.

MILLSTONE EAST. **Eleva., 44.70 ft.**
On the center of a property monument set on the westerly side of Market Street about 200 feet southerly from Amwell Road and marking the line of the Marino and Canal properties. The stone is at the face of the frame building and leans slightly from the vertical.

NORTH BRANCH. **Eleva., 90.09 ft.**
Copper bolt on the third stone step from the top on the east end of southerly abutment of Central Railroad bridge over a farm road about one mile southeast of the station.

NORTH BRANCH. **Eleva., 91.15 ft.**
A cross cut on the outer corner of the third stone step from the top and about six inches below the girder seat on the westerly end of southerly abutment of railroad bridge over a farm road about one mile southeast of the station.

NORTH BRANCH. **Eleva., 127.01 ft.**
Copper bolt on the fourth stone step from the top on the northerly end of westerly abutment of railroad bridge over farm road about one and one-quarter miles northwest of the station.

NORTH BRANCH. **Eleva., 129.38 ft.**

TAN. **Eleva., 103.99 ft.**
oss near the northwest corner of concrete foundation of signal for ind trains of the Central Railroad about one mile west of the
L

Y HILL. **Eleva., 86.92 ft.**
oss on the outer corner of stone on the west end of south parapet iway culvert on the main street about 30 yards west of Rocky Hill the junction of the road to Kingston.

RVILLE. **Eleva., 48.18 ft.**
ss on the southwest corner of large stone near the southerly end of theast abutment of South Branch Railroad bridge over Raritan The stone forms the seat of the southerly truss.

RVILLE. **Eleva., 73.60 ft.**
e extreme easterly end and corner of bottom step at entrance to ond National Bank opposite the court house yard. The point is at ht-angle turn in the step at the corner of the streets. The base orch columns rests on this step.

RVILLE. **Eleva., 73.05 ft.**
ss on the westerly end of door sill of Main Street entrance to the ational Bank on the corner of Main and Maple Streets.

RVILLE. **Eleva., 63.29 ft.**
projection of flagstone at the top of stone foundation at the southner of a red-brick structure about 50 yards westerly from the railtion and on the northerly side of the tracks.

RVILLE. **Eleva., 56.53 ft.**
ss on the outer corner of the bottom stone step at the westerly end erly abutment of railroad bridge over Somerset Street about onele northwest of the station. The stone forms the first step above ling wall along the north side of the street.

RVILLE. **Eleva., 81.90 ft.**
nd center of metal disc set in "true meridian" granite post in the ouse grounds at the main entrance to the new court house.

SECONDARY BENCH MARKS.

NG RIDGE. **376.5 ft.**
at station.[1]

ILLS. **167.2 ft.**
at station.

TONE. **228.0 ft.**
at station.

L. **309.8 ft.**
at station.

BROOK. **218.0 ft.**
at station.

CK. **198.2 ft.**
at station.

---

at station" means rail joint nearest the center of the station.

SUSSEX COUNTY.

BRANCHVILLE JUNCTION. **Eleva., 581.7**
A cross on the southwest corner of concrete slab about 50 feet n the north face of the station, about six feet above and 15 feet easterl the east rail of the Branchville branch of the Lackawanna Railro

FRANKLIN. **Eleva., 581.2**
A cross on the outer edge at the west end of bottom concrete six steps leading from the Stockholm road into the yard of the property on the northeast corner of the intersection of the Frankli nace-Stockholm roads about one mile southerly from Franklin Furna

FRANKLIN. **Eleva., 604.2**
Top edge and center of marble slab set in the west face and n southwest corner of the Presbyterian Church on the street leading Zinc Company's property and offices. The tablet reads A. D. 1914.

FRANKLIN. **Eleva., 558.3**
A cross cut in the northwest end of the granite sill of the front e to the old public school.

(Note correction in elevation given in Bul. 17.)

SECONDARY BENCH MARKS.

BEAVER LAKE. **964**
Rail at station.

FRANKLIN FURNACE. **536.**
Frog of the N. Y., S. &. W. and the D., L. & W. Railroads at thei tion about 0.25 mile north of the station.

STOCKHOLM. **976**
Rail at station.

STOCKHOLM. **982.5**
Cross on guard stone at northeast corner of J. M. Lewis', store.

UNION COUNTY.

ELIZABETH. **Eleva., 27.3**
Copper bolt three feet from the girder and above the bridge seat top step of a series of steps on the northerly end of east abutment

FIELD. **Eleva., 109.53 ft.**
ss on the outer corner at the northeast end of door sill of the y entrance to the First Presbyterian Church on East Front Street Church Sreet.

IELD. **Eleva., 105.93 ft.**
outer edge and at the center of the most northeasterly entrance northwest face of the Second Presbyterian Church at Crescent nd East Seventh Street.

IELD. **Eleva., 104.27 ft.**
outer edge near the southerly end of door sill of E. Sixth Street to parish house of Grace Protestant Episcopal Church at East eet and Sycamore Avenue.

IELD. **Eleva., 101.45 ft.**
on the outer edge at the southeast end of door sill of entrance on Avenue to the police headquarters near the railroad station.

Eleva., 290.61 ft.
on the second stone from the northeast end of the westerly para- nall railroad bridge over water course at the highway crossing D., L. &. W. station at West Summit. The mark is 5.7 feet from

Eleva., 257.98 ft.
s on the northwest corner of bedplate stone on the north end butment of D., L. & W. railroad bridge over a highway about rters mile southwest of the West Summit station.

ELD. **Eleva., 122.65 ft.**
s on cement sidewalk directly below the northeast corner of the Trust Co.'s building at Elm and East Broad Streets. The mark left of the corner entrance and about 6 inches below the door

ELD. **Eleva., 128.31 ft.**
bolt in flagstone coping at the entrance to the tunnel on the le of the railroad tracks at the station.

SECONDARY BENCH MARKS.

EY HEIGHTS. **230.4 ft.**
f crossing at the station.

Y HILL. **253.4 ft.**
station.

UMMIT. **295.3 ft.**
t station of D., L. & W. Railroad.

WARREN COUNTY.[1]

EWATER. **Eleva., 441.45 ft.**
s 5.5 feet from the rail of track on the west end of south con- tment of Delaware, Lackawanna and Western Railroad bridge conetcong River. The cross is at the angle formed by the abut- l wing wall.

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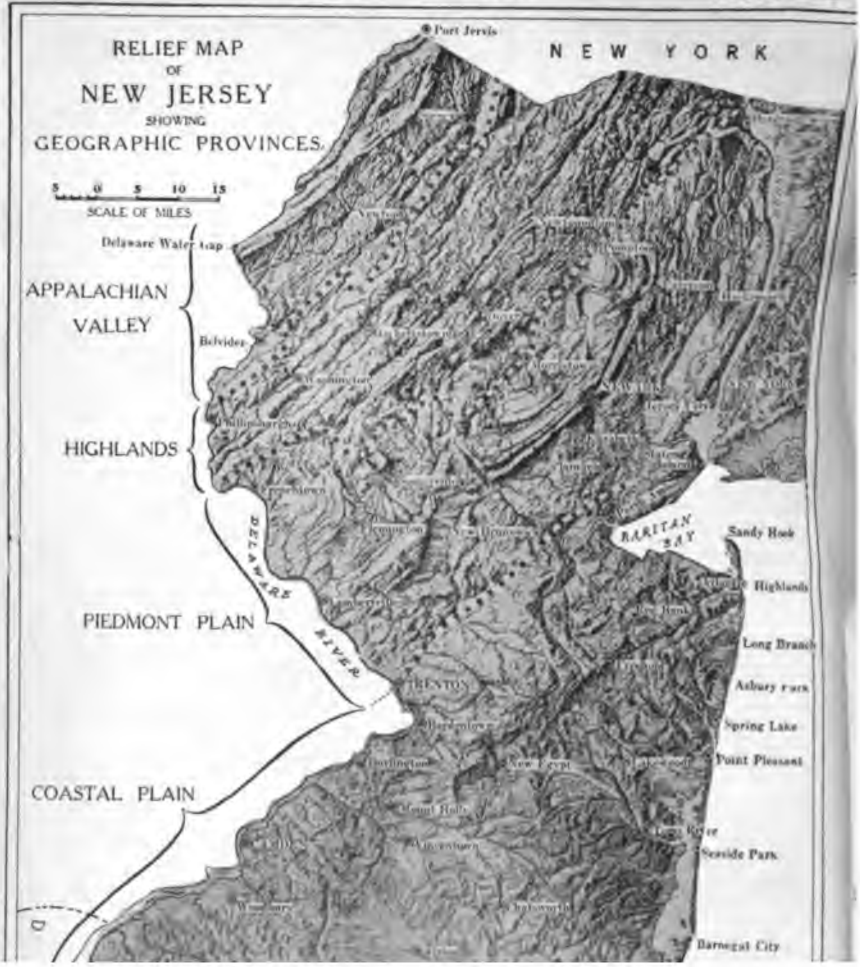
lletin 17, 1916, for principal revised list of bench marks in Warren

CHANGEWATER. **Eleva., 437.46 f**

A cross four feet from the west rail and about 3.5 feet below the l of the track on the outer corner of bridge seat at the west end of no abutment of Delaware, Lackawanna and Western Railroad bridge o Musconetcong River.

CHANGEWATER. **Eleva., 466.41 ft.**

A cross near the outer edge and 10 inches from the southerly end the northeast abutment of highway bridge spanning the railroad abou one-quarter mile northwest of the station.



RELIEF MAP
OF
NEW JERSEY
SHOWING
GEOGRAPHIC PROVINCES.

Jersey

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF SOILS—MILTON WHITNEY, Chief.

COOPERATION WITH THE DEPARTMENT OF CONSERVATION AND DEVELOPMENT OF NEW JERSEY, HENRY B. KUMMEL, STATE GEOLOGIST;
NEW JERSEY AGRICULTURAL EXPERIMENT STATION,
JACOB G. LIPMAN, DIRECTOR.

OIL SURVEY OF THE MILLVILLE AREA, NEW JERSEY.

BY

C. C. ENGLE, In Charge, L. L. LEE, and H. A. MILLER, of the Department of Conservation and Development of New Jersey, and AUSTIN L. PATRICK, J. M. SNYDER, and HOWARD C. SMITH, of the U. S. Department of Agriculture.

HUGH H. BENNETT, Inspector, Southern Division.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., December 11, 191

Sir: I have the honor to transmit herewith the manuscript re
and map covering the survey of the Millville area, New Jersey,
to recommend that they be published as advance sheets of F
Operations of the Bureau of Soils, 1917, as authorized by law.
work was done in cooperation with the Department of Conserva
and Development of New Jersey.

Respectfully,

Milton Whitney,
Chief of Burea

Hon. D. F. Houston,

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FIG. 1. Sketch map showing location of the Millville area, New Jersey ----
2. Sketch map showing distribution of soils by texture ----

MAP.

EY OF MILLVILLE AREA, NEW JERSEY.

**In Charge, L. L. LEE and H. A. MILLER, of the Department
and Development of New Jersey, and AUSTIN L. PATRICK,
and HOWARD C. SMITH, of the U. S. Department of Agricul-
:cted by HUGH H. BENNETT.**

DESCRIPTION OF THE AREA.

area comprises the extreme southern part of New
ıdes all of Cape May County, two-thirds of Atlantic
hree-fourths of Cumberland County, and small parts
ıd Salem Counties. It is bounded on the north by
north latitude, on the west by meridian 75° 12′ west
ın the other sides by Delaware Bay and the Atlantic
ıng the Cape May Penin-
average length from east
.iles and an average width
ɔuth of 25 miles. The dis-
north boundary to the tip
ay Peninsula is about 42
vey comprises all of atlas
, and 37 of the New Jersey
vey, and has an extent of
les, or 641,280 acres.

area as a whole is flat to
ıg, and characterized by a
The northwestern part
along the Maurice River
elief. They merge gradu-
belt, 3 to 8 miles wide,
vare Bay. The eastern half of the area, including the
ısula, is more nearly level, but there is no such distinct
upland along the Atlantic shore as along the north
'e Bay. There are many large, swampy depressions
area, the most notable lying near Dividing Creek,
Weymouth.

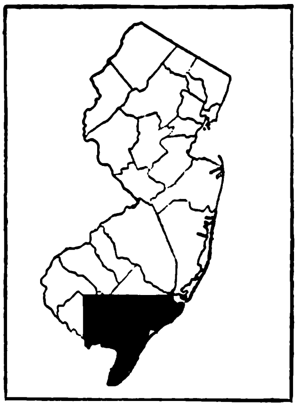

FIG. 1.—Sketch map showing location of the Millville area, New Jersey.

elevation is from sea level to a maximum of 141 feet,
vation of a knob 2¼ miles south of Husted, in the
rner of the area. The general slope is to the south,
'e Bay, and to the east toward the Atlantic Ocean.

(See Pl. I.) The drainage is separated by a divide which exte in a general southerly direction from Landisville through Halbert Woodbine, Sea Isle Junction, and Cape May Court House to W Cape May. This divide is not a distinct ridge at any point. is generally a broad, smooth belt, varying in width from abou miles in the northern part of the area to 1 mile or less on the lo end of the Cape May Peninsula, and only slightly elevated ab the surrounding country.

Three important rivers—the Tuckahoe, the Great Egg, and Mullica—receive most of the Atlantic drainage. They have their way to tide level for a distance of 15 to 20 miles back fr the ocean, and are sluggish and meandering. They and their tri taries are bordered by, and have their sources in, flat, swampy ar The Tuckahoe and Great Egg Rivers empty into Great Egg I just west of Ocean City. The Mullica River, lying outside area surveyed, empties into Great Bay just north of the area s veyed. The Maurice River collects most of the drainage to west of the divide, and empties into Maurice River Cove, a part Delaware Bay. It is a tidewater stream 15 miles inland to Mi ville, where it forms the outlet of Union Lake. Dividing Creek Dennis Creek also receive drainage from the Delaware Bay basin.

Nearly all parts of the Millville area have adequate drainage cept certain flat regions on the main divide, such as those in vicinity of Woodbine and Richland and west of Burleigh, and flat belt bordering Delaware Bay. Much of the flat region ab Tuckahoe and Marshallville can also be described as imperfect drained.

open growth in which fairly tall oaks and pines are nearly
n number. Other areas are covered with a dense growth of
ne, both a bushy or scrubby sort and many of larger size,
ng perhaps 30 feet in height. Plate II shows a quite typical
scene, and illustrates well the character of the underbrush.
s much sassafras and some hickory, and in the southern part
area holly is plentiful. Huckleberry covers the ground more
thickly nearly everywhere. Other species of greater or less
ance are bracken (*Pteridium aquilinum* L.), greenbrier (*Smi-*
uca Walt.), sweet fern (*Comptonia asplenifolia* L.), sheep
or mountain laurel (*Kalmia angustifolia* L.), staggerbush
marina L.), arbutus (*Epigaea repens* L.), and wild indigo
sia tinctoria L.). There are also many grasses, sedges, and

There is little difference in the natural vegetation on the
upland soils.

ing definite is known in regard to the settlement of Cape May
prior to 1691, but about this time a number of settlers came
ong Island, having been attracted chiefly by the excellent
fishing in Delaware Bay. The population has steadily in-
from 1,004 in 1738 to 5,324 in 1840, and 19,745 in 1910.
y-nine per cent of the population consists of native-born white
s, 13.7 per cent of foreign-born white persons, and 7.3 per cent
roes. The foreigners are mainly of Russian, Italian, German,
or English stock. The county is most thickly settled on the
la, along the Atlantic border, along the north shore of Dela-
Bay, and along the northern border. The northwestern part
sely settled. The population averaged 74.5 persons to the

of cedar, oak, and pine, and by the abundance of fish, oysters, an
clams in the adjacent waters. The population of the county
1910 was 71,894. Sixty-nine per cent of the inhabitants were nati
born white persons, 15.9 per cent foreign-born white persons, and
per cent colored. The foreign nationalities represented are main
Italian, German, Irish, Russian, and English. Only 22.6 per ce
of the population of Atlantic County is rural, and on the whole
is sparsely populated, especially in the central portion. The avera
number of rural inhabitants per square mile is only 28.6, and th
farming communities are concentrated along the railroads and alon
the eastern and southern borders. The large proportion of foreigne
is partly explained by the cosmopolitan character of the large reso
towns, but there are many farming communities made up largely
nonnative stock. Atlantic City, with a resident population of 46,15
is the largest city in the Millville area. It is the largest summ
resort in the eastern part of the United States and has a larg
patronage in the winter as well. Mays Landing, the county seat
Atlantic County, is one of the oldest towns in the area, having bee
founded in 1710. It has a large cotton mill but is not important
an agricultural center. Its population in 1910 was 1,389. Pleasant
ville, with a population of 4,390, and Egg Harbor, with 2,18
inhabitants, are of some importance as farming centers and als
industrially.

Cumberland County was formed from part of Salem County i
1747. Its population in 1840 was 14,363, and in 1910, 55,153. Th
early settlers in this county were attracted by the forests and th
maritime and agricultural opportunities. They came largely fro

g and agricultural center, with a population in 1910 of 5282.
nall towns of more or less importance agriculturally are Port
which is near the important oyster-shipping point of Bivalve:
lle; Newport; Dorchester; and Leesburg.[1]

ransportation facilities of the area are very good. The area
l by seven railroads. A line of the Central Railroad of New
running through Landisville and Vineland from Bridgeton
uch fruit, truck, poultry, and eggs to New York from the
d district and elsewhere. A branch extends to Bivalve, an
nt oyster-shipping point at the mouth of the Maurice River.
re four lines of the West Jersey & Seashore Railroad, one
the northwestern corner of the area and ending at Bridge-
second, extending to Millville and Cape May, and connect-
Manumuskin Station with Bivalve and at other places with
shore resorts; a third, electrified, reaching to Richland,
anding, and Atlantic City; and a fourth serving Egg Har-
Atlantic City. The Atlantic City Railroad has two lines
area. One runs south through Richland to various Atlantic
esorts, and terminates at Cape May. A second touches Egg
and terminates at Atlantic City. There are several trolley
e connecting Vineland, Millville, Bridgeton, and Port Norris,
other connecting Atlantic City and Pleasantville with shore
o the south.

public highways of the area as a whole are in excellent condi-
Nearly all the main roads are improved, largely with gravel.
y are wide and well graded. They are free from stones and
t well scraped during the wet months of the year. These
ave one disadvantage; they become soft and easily rutted in
 weather.

he settled parts of the area are supplied with telephone

larger streams are navigable for small craft and barges 5 to
s up their courses. Prior to the railroad building, which took
out the middle of the nineteenth century, nearly all the trans-
on from the inland region to the cities was by water.

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this report was written the preliminary announcement of the population of

The chief markets within the area are the many shore resorts as Atlantic City, Ocean City, Wildwood, and Cape May. A l amount of food products is hauled to these places by motor truc railroad. Much produce is consumed also by such towns as V land, Millville, Bridgeton, Pleasantville, Egg Harbor, and C May Court House, and the smaller towns afford local markets. O side the area New York City, 190 miles away, is the chief mar with Philadelphia second.

Most of the agricultural communities are provided with cann plants. Bridgeton, just outside of the area, has nine such pla All of them can tomatoes, and five in addition can one or more the following: Kieffer pears, pumpkins, beans, squash, beets, rhubarb. In Cedarville there are two canning houses, one of wh puts up tomatoes and peas, and the other tomatoes, peas, and be Newport has a tomato-canning plant. Vineland has one plant, c ning tomatoes, peaches, and berries. A plant in Fairton, just out the area surveyed, on the west, cans tomatoes and cherries. In C May there are six canning factories, the principal products be tomatoes, peas, and lima beans. A plant at Rio Grande cans to toes. There are two canneries at Goshen and two at Eldora, handl tomatoes, pumpkins, and lima beans. At Egg Harbor, in Atla County, a plant cans tomatoes and pears. There are two toma canning plants at Landisville, and one of these in addition c small fruits and peaches.

CLIMATE.

The Millville area has a milder climate, with a longer grow

Average and extreme dates of killing frosts, Millville area.

Weather Bureau station.	Average date of last in spring.	Average date of first in fall.	Latest recorded in spring.	Earliest recorded in fall.
Atlantic City	Apr. 10	Nov. 4	Apr. 25	Oct. 1
Bridgeton[1]	Apr. 19	Oct. 23	May 12	Oct. 1
Cape May	Mar. 30	Nov. 16	Apr. 11	Nov. 1
Vineland	Apr. 18	Oct. 20	May 22	Sept. 22

[1] Just west of the area.

plete climatic data for two stations within the area, Vineland
north and Cape May in the south, are given in the following

monthly, seasonal, and annual temperature and precipitation at Vineland.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1914).	Total amount for the wettest year (1902).
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
	34.4	68	—5	3.84	6.26	6.85
	32.0	71	—11	3.77	4.17	3.81
	32.5	71	—13	4.05	2.47	7.37
ter	33.0	71	—13	11.66	12.90	18.03
	40.3	87	—6	4.16	2.02	4.45
	50.7	97	21	3.34	3.23	3.61
	62.2	98	29	3.77	1.44	1.35
ng	51.1	98	—6	11.27	6.69	9.41
	71.6	102	41	3.58	1.46	8.16
	76.4	105	47	4.51	4.22	3.68
	73.6	104	46	4.97	5.20	2.10
mer	73.9	105	41	13.06	10.98	13.94
r	66.9	101	32	3.85	.28	5.44
	55.4	92	22	3.46	1.66	5.37
r	43.9	80	12	3.30	1.88	3.72
	55.4	101	12	10.60	3.82	14.53
r	53.3	105	—13	46.59	34.39	55.91

Normal monthly, seasonal, and annual temperature and precipitation Cape May.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1903).	Si av de
	°F.	°F.	°F.	Inches.	Inches.	Inches.	In
December	38.0	64	10	3.78	2.33	3.52	
January	34.1	65	2	3.37	3.51	4.45	
February	34.1	64	5	3.39	1.68	5.65	
Winter[1]	35.4	65	2	10.54	7.52	3.62	
March	40.8	68	12	3.91	3.34	6.25	
April	48.4	83	28	2.99	3.68	2.40	
May	58.6	91	41	2.99	2.85	1.13	....
Spring	49.3	91	12	9.89	9.87	9.78	
June	67.7	95	46	3.04	0.93	4.48	....
July	73.4	94	55	3.78	2.84	6.49	....
August	73.4	95	53	4.26	0.86	6.70	....
Summer	71.5	95	46	11.08	4.63	17.67	....
September	69.0	92	42	3.00	0.49	4.66	....
October	59.6	82	34	3.30	2.41	4.67	....
November	48.2	74	24	3.22	2.31	1.93	
Fall	58.9	92	24	9.52	5.21	12.26	
Year	53.7	95	2	41.03	27.23	53.33	

[1] Record for 16 years at Cape May Court House.

driest year on record in the whole area was that recorded at
lay in 1895, when only 27.23 inches of rain fell, while the wet-
ıs recorded at Atlantic City in 1903, when the precipitation
ted to 61.11 inches.

AGRICULTURE.

early settlers in this region were probably attracted more by
ɜ fishing and whaling in the near-by waters and by the timber
:es and the opportunities for shipbuilding than by the agri-
ıl possibilities of the region. The first crops grown were
bles, corn, wheat, oats, and rye. The settlements were con-
aainly to points easily reached by water, but with the estab-
: of glass factories, iron foundries, and other industries,
roads and later railroads were extended into the inland
s.

agriculture of the area has followed the development of mar-
nd with the growth of large centers of population in the east
e large resorts along the Atlantic shore there has been a fall-
' in the production of general farm crops and an increase in
ıg. The change between 1880 and 1910 is illustrated in the
data for Cape May County. This county lies wholly within
ea surveyed and fairly represents the included portions of
ic and Cumberland Counties.

n 1880 to 1910 corn decreased in acreage from 4,996 to 4,090
hay from 4,302 to 3,587 acres, wheat from 1,543 acres to zero
ts from 335 to 24 acres, while Irish potatoes increased from 442
acres, and sweet potatoes from 301 to 445 acres. In 1880 about
cent of the cultivated acreage was devoted to corn, hay, wheat,
ts, while by 1910 the percentage was reduced to 72. The acre-
merly devoted to wheat has been entirely supplanted by truck
and the acreage withdrawn from the other general farm crops
en similarly absorbed. When wheat growing was important
were a number of local grist mills in operation. In Atlantic
ʏ[1] cereal production never was as important as in Cape May
ımberland Counties. The corn acreage in 1910 was practically
ne as in 1880, while the acreage in hay was larger. The other

There has been a gradual increase in the value of farm propert in this area, except between 1890 and 1900, when farm values wer low. The value of farm animals and implements also shows a gradual increase, and land values nearly doubled between 1900 and 191 In Atlantic County the total value of farm animals has fallen o greatly since 1880. The census of that year reports domestic animal as representing 20.6 per cent of the total farm value, while by 191 the figure had been reduced to 6 per cent. The next census will n doubt show a great increase in the value of farm property, judgin from present conditions.

One of the most significant changes since 1880 has been a reductio in the average size of the farms. In Cape May County the averag size decreased from 95 to 66.6 acres. This has been brought about i large measure by the change to an intensive type of farming. Ther has been a corresponding increase in the total number of farm from 547 to 632.

The Millville area is essentially a trucking, fruit, and poultry district. According to the census for Cape May County, grains an hay constituted 22.6 per cent of the value of all agricultural products in 1909, animal and dairy products 14.6 per cent, vegetables 29. per cent, poultry and eggs 18.8 per cent, and fruits and nuts and othe crops 14.5 per cent. In the other counties the percentages are ver similar, except that in Atlantic County the proportion of fruits an nuts is much higher.

Corn is the only cereal which occupies a large acreage. The cro is fed to farm animals or sold locally. Nearly every farmer devote 5 to 15 acres to corn. A small acreage of wheat is grown at th eans, and lima beans, with sweet corn, asparagus, water- cantaloupes, rhubarb, lettuce, cabbage, horse beans, and some importance. Strawberries, peaches, blackberries, dew- grapes, apples, and cranberries are the principal fruits.

ing and hog raising are not carried on to any important ex- here are practically no dairy herds in Atlantic County, only ı Cape May County, and but few in Cumberland County. airy farms are located mainly along the Maurice River, and k is pastured on Reclaimed tidal marsh. High-grade Hol- ws, with a few Guernseys, make up the herds, each of which d by a purebred bull. Most farmers keep one cow or goat, w hogs, which are rarely of purebred stock. There are, how- few purebred Berkshire hogs in Cape May County.

oultry industry is highly developed throughout the area. ef breed is the White Leghorn, but fowls of heavier breeds ; for table use. In the vicinity of Vineland poultry raising is f industry. The average flock includes 600 to 700 laying d there is an average return of about 100[1] eggs per hen per he eggs are shipped by express to New York City, and bring ces. The green feed needed is grown in the runs, which 8.4 acres. Other feeds are purchased. Green foods grown ter use are mangelwurzels, cabbage, and kale.

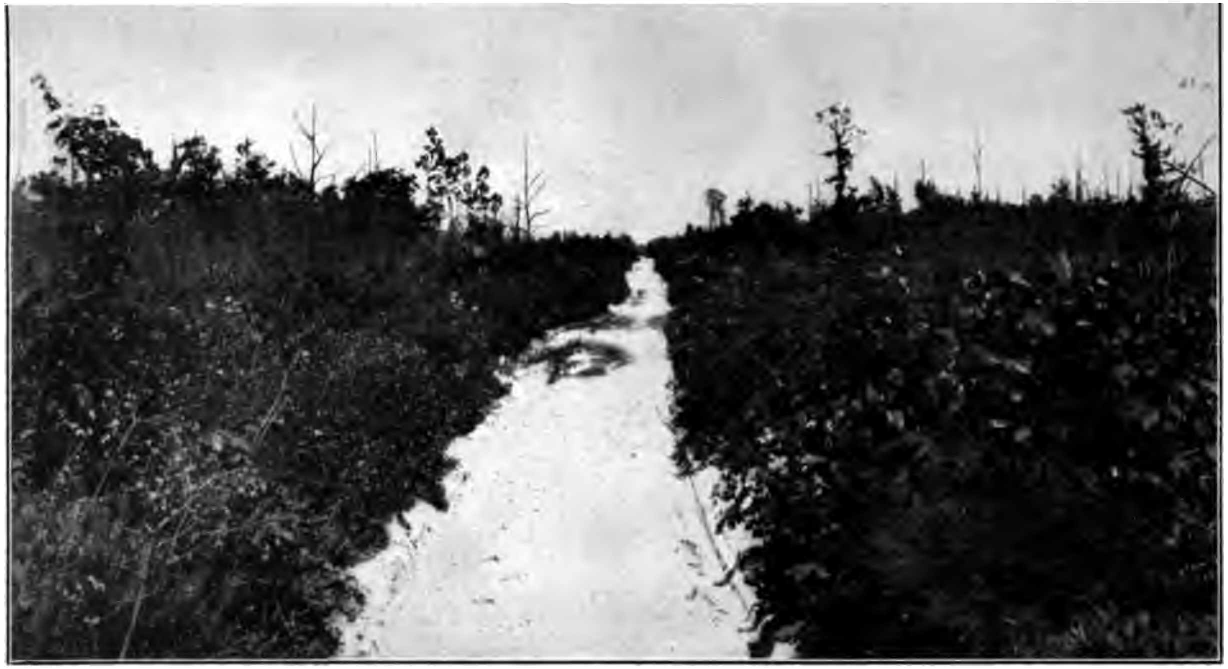
graphic variations have little influence upon crop production rea except as they have influenced soil formation. The topog- s considered to some extent in the selection of the more areas for orchard sites, and it ought perhaps to be given more ation than it receives. For example, areas well elevated e general water level should be selected for crops which will ast from drought. Nearly all the crops are grown on every

adapted to them, but keep to Irish potatoes, sweet potatoes, pep
beans, and other crops which can be hauled more or less at le
and in large quantities.

Cereal production in the Millville area is largely confined t
growing of yellow dent corn, though some rye is grown. (Plat
fig. 1.) Corn is planted by hand, in hills 4 feet apart each
Planting lasts from May 20 to June 10. In many sections
is fertilized lightly or not at all. When it is grown on sod 1
12 tons of manure per acre is sometimes used, and where it doe
follow grass 600 to 1,000 pounds of a 3–8–10[1] fertilizer. The f
lizer is generally put in the hill after a little earth is thrown
the seed, and it is very seldom broadcasted. Plate III, figur
shows a good stand of corn on the Sassafras gravelly sandy loa

The hay crop consists of red and alsike clover, timothy, and alf
Mixed hay is commonly cut in June and October. Salt hay is
in summer if the meadows are dry, otherwise in winter. Alf
is cut three and occasionally four times a year. The crop is
monly seeded about August 20, after potatoes or beans, at the
of 25 to 35 pounds per acre. It is left down eight years or lo
when the stand is good.

Early and midseason Irish potatoes are planted as soon as dan
of frost is past. Two-horse planters are used in large fields,
much of the planting is done by hand. The crop is given l
cultivation until about June, when it is ridged. Irish Cobb
Rural New Yorker, Green Mountain, Mills Pride, Early Rose, B
bank, and True Fortune are the principal varieties planted for
early crop, but at least one-half of the crop is of late planti



SHOWING CHARACTER OF THE "BUSH" OR WOODS.

The undergrowth is typical, but usually there is more pine or oak of small size. Much of the wooded area is burned over annually. Some trees killed by fire are shown in this illustration.

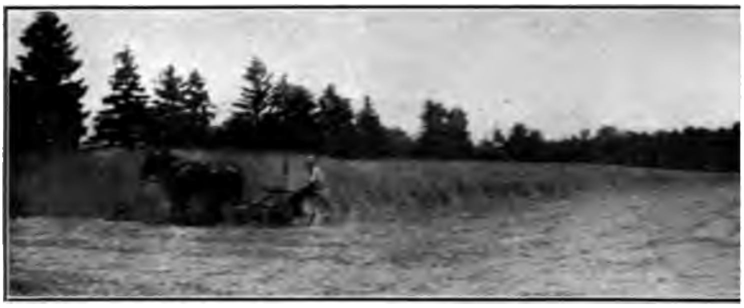


FIG. 1.—RYE ON SASSAFRAS GRAVELLY SANDY LOAM.

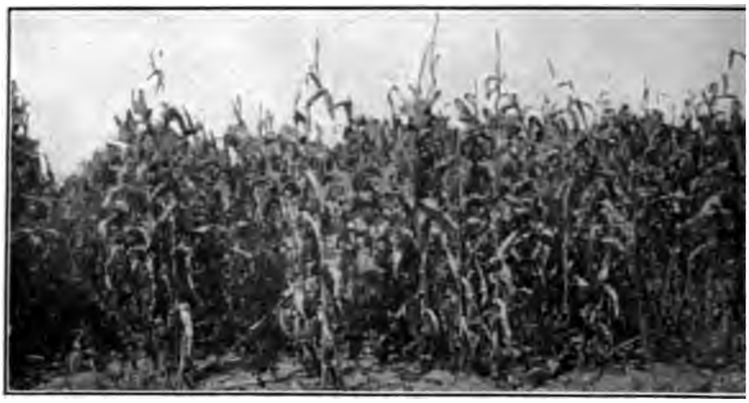


FIG. 2.—CORN ON SASSAFRAS GRAVELLY SANDY LOAM.

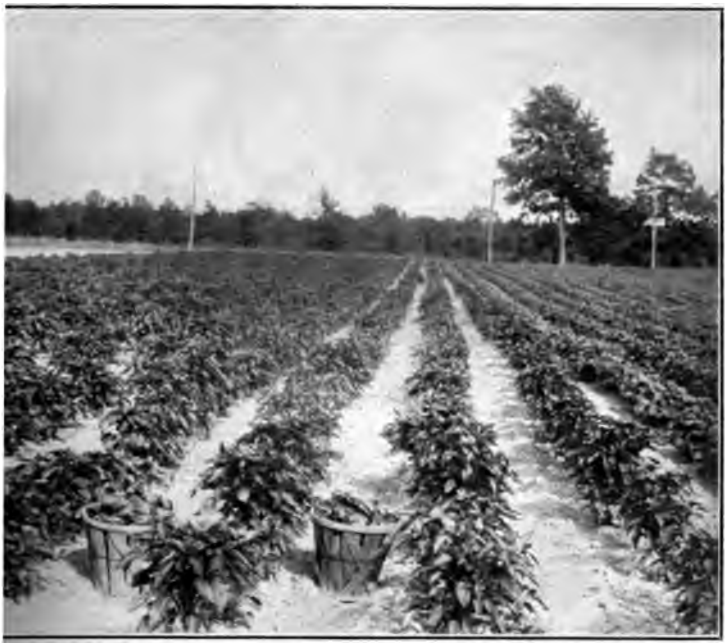
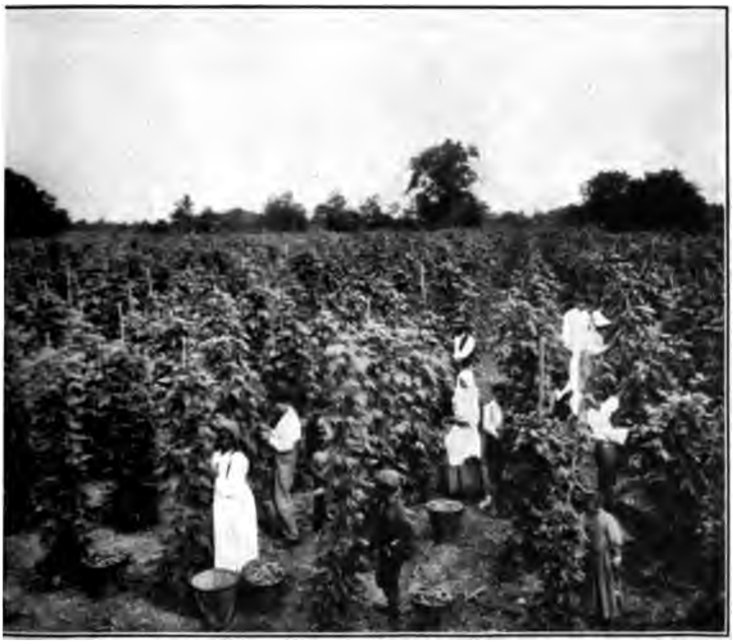


FIG. I.—PEPPERS ON SASSAFRAS LOAMY SAND.



ᵓOLE LIMA BEANS ON SASSAFRAS GRAVELLY SANDY LOAM, FLAT PHASE.

the vines first being removed. Yellow and red skin potatoes
e grown. They are graded into primes and culls and either
l in bushel hampers (as shown in Plate III, fig. 3) and bar-
stored and held for winter sale.

to seed is sown in hotbeds about April 15, and the plants are
about June 1 for the late crop and May 10 for the early crop.
e set about 4 feet apart each way. Some planting is done by
. Manure is generally used for tomatoes, at the rate of 6 to
r more per acre. The brand of fertilizer used varies con-
y, but in normal times averages about 2-8-10. The acreage
ions vary from 200 to 600 pounds. Most farmers place the
r in the hills, although some is broadcasted. It is usually
ented with about 100 pounds of nitrate of soda, applied to the
en the fruit is setting. On the poultry farms a mixture of
nds of acid phosphate and 1 ton of poultry manure is often
at the rate of 400 to 1,000 pounds per acre. In some parts
rea one-half ton of fish guano is used with the manure. The
first given frequent level cultivation, which is deep at first
llow later. The great bulk of the tomatoes is of late vari-
d are sold to local canners or shipped to those in Camden
more. Many are shipped by water from such points as Port
nd Bridgeton. The most common varieties of late tomatoes
Greater Baltimore, Cumberland Red (local in Cape May
mberland Counties), Stone, Ponderosa (or Beefsteak), and
ss. The early varieties are chiefly the Earliana, Chalks
ewel, and Bonny Best.

t corn is grown to a considerable extent for the shore markets.
liest variety is Crosbys Early, which is really not sweet corn
ariety of flint. Other common varieties grown are Country
an, Stowells Evergreen, and Golden Bantam.

er seed is planted in hotbeds in late February or in March.
plants are set out, in rows about 3 feet apart, as early as May
as late as July 1. They are spaced 12 to 24 inches apart, de-
upon the variety and soil. Plate IV, figure 1, shows a good
peppers on a Sassafras soil. The fertilization and cultiva-
similar to that given tomatoes, and depends upon the soil.
s are sometimes grown as an intercultivated crop in orchards,
n in Plate V, figure 2. Harvesting begins about July 1 and
es until November or until frost. Peppers are an excellent
grow where labor is short, as picking can be delayed a con-
le time. The crop is shipped in hampers or in barrels. Half-
oxes or southern pepper crates are used to a large extent, as
ave a more attractive appearance than the barrel. Sweet
s are grown most extensively. The chief variety is the Ruby

King. Others are Bull Nose, Cheese, Cuban, Italian White C Chinese, and Long Sweet. The Cherry, Long Hot, Chinese Hot, a Finger varieties are the principal varieties of hot peppers grown.

Onion growing is most highly developed in the southwestern p of the area. About 20,000 bushels are annually produced in the M ville area. The lighter soils are preferred for onions because t careful cultivation necessary is easier. The crop is grown larg from sets, since in order to get a good price it must reach the mar by June 20 or July 1, ahead of the Long Island and New York St crops, and when seed is used it does not mature until August The field intended for onions is plowed in March to a depth of 6 t inches. The sets are put in rows 2 feet apart in the latter part March. The sets heretofore used have come mainly from Ohio a New York, but many farmers are now growing their own. The se for sets is sown at the rate of 60 to 70 pounds per acre and yields much as 400 bushels per acre. The sets are harvested in July a stored in a dry place for use the following year. The onion crop weeded by hand until 3 or 4 weeks after setting, when 1-hor shallow-toothed cultivators are used. Onion fields are often lim at the rate of one-half ton to the acre, and two applications of fert lizer are usually made, the first one consisting of about 400 pounds a 4-8-10 mixture and the later one of 300 pounds of a 2-8-10 mixtu broadcasted. Another preparation in common use analyzes 3 p cent nitrogen, 7 per cent phosphoric acid, and 7 per cent potash. the Cedarville and Newport district onions are often grown in the san field for seven or eight years continuously, but cover crops are usual sown after the crop is removed. Plate VIII shows a crop of onio

'ay. Two vines are allowed to the hill. The crop is heavily
ed with both manure and commercial goods, the latter being
in the hill. A common method is to make a very early plant-
l two plantings later, to insure a good stand. A first-class field
lima beans is shown in Plate IV, figure 2, and a good field of
beans in Plate V, figure 1.

y market peas and canning peas are of more or less im-
ce in all parts of the area. The early crop is seeded as soon
danger of frost is past, and the canning crop later. Peas are
quite extensively in the Cape May district. They are manured
rtilized with 400 to 800 pounds of a fertilizer analyzing
to 3-8-10. The canning variety mainly grown is the Alaska.
irly market varieties are the Telephone, which is the most
ant, and the Gradus, Alaska, and Potlatch.

peach orchards in the area are generally well cared for, and
glected orchards are to be seen. A variety of truck crops are
in the orchards for two or three years, or until the trees come
aring. Plate V, figure 2, shows a typical young orchard with
s between the rows. There is much variation in the fertilizer
es in different parts of the area. In the western part, exclud-
e Vineland district, about 600 pounds of bone meal and 6 tons
iure are used per acre. In the Vineland district many farmers
out 400 pounds of acid phosphate, often mixed with poultry
e, 200 pounds of muriate, and about 100 to 200 pounds of ni-
f soda. More nitrate is used on young orchards. In the east-
irt of the area some farmers depend mainly upon manure,
s combinations of nitrate, acid phosphate, and raw and
d bone. The nitrate is applied after the fruit sets, at the rate
to 300 pounds per acre. The best growers spray four or five
using commercial lime sulphur in the first two treatments and
mixed in the later ones. Arsenate is added in one or two
ngs. Atomic sulphur is becoming very popular, as it is said to
etter fruit and in addition is a great labor saver. The bulk of
ach crop is shipped to New York in either the Georgia carrier
Michigan bushel and half-bushel basket. The hamper is used
for inferior fruit. At the present time it costs 23 cents to ship
uart carrier from Vineland to New York, and about 5 cents must
led to this for carting. Special trains are run by the Central
ad of New Jersey from the peach and fruit district of Vine-
to New York during the harvest season. About one-third
present plantings in the Vineland district, which is probably
representative of the whole area, consists of the Elberta vari-
A survey of this district recently made shows plantings as fol-
Elberta (midseason), 43,503 trees; Carman (early), 22,921;
of Georgia (midseason), 13,387; Champion (midseason),

11,750. Other varieties, named in the order of their importan are the Iron Mountain (late), Greensboro (early), Ray (late), Hi (midseason), Krummel (late), Late Crawford, Lola (early), F Seedling (late), Hale (midseason), and Mountain Rose. Thirty- other varieties are listed in the district.[1]

Cranberries are grown largely on the soil mapped as Swamp. T areas are cleared, diked, and flooded for several years to kill the wee before the vines are planted. If well cared for they produce fo long period of years. Cranberries are sold mainly through an as ciation. There were reported in Cape May County in 1909, 328 ac of cranberries, producing 600,736 quarts, with a value of $29,174.

The Kieffer pear is the only variety grown extensively. The cr is of low quality and is sold largely to canners. Many orchar however, are well sprayed, fertilized, and cultivated, and are prof able. In recent years the pear orchards have been damaged by t blight.

Grapes are an important crop locally, as in the vicinity of Vin land, East Vineland, Egg Harbor, Woodruff, and Woodbine. Th are grown in rows about 5 or 6 feet apart, and the vines are ti to wires stretched from posts in the rows. The principal varieti are the Ives and Concord.

Blackberries, raspberries, and dewberries are grown extensively Atlantic County. In Cumberland County blackberries and dewbe ries are important. They are fertilized rather heavily and give level cultivation. Plate VI, figure 1, shows an excellent patch blackberries in bloom on a Sassafras soil.

Strawberries are grown extensively throughout the area. The are some patches as large as 20 acres, but they usually range from

and of cantaloupes.
rms of the Millville area are only moderately well equipped,
the smaller farms a large amount of hand labor is necessary.
getable storage space is needed on most farms, especially for
tatoes and Irish potatoes. Only one or two work horses are
the average farm, and they are generally of light draft.
ethods of cultivation are followed throughout the area.
re cultivated as soon as possible after every rain, and in the
of rain the period between cultivations is not often longer
e week.

te rotations are not generally followed, especially in the
part of the area, but in Cape May County a systematic rota-
racticed to some extent. A cover of rye and vetch or crim-
er is sown in the corn at the last cultivation. It is turned
e next year for late potatoes, which are followed by rye, and
urned under for an early truck crop the third year. Grass
y followed by corn or potatoes. Early peas are followed by
atoes. In Atlantic County sweet potatoes are often grown
usly for a period ranging from 3 to 20 years. Occasionally
t has been in sweet potatoes is heavily manured and given
a truck crop for one year, after which sweet potatoes are
or another period. In Cumberland County sod land is usu-
nted to corn, which is followed by potatoes, tomatoes, or
otatoes are followed by wheat, alfalfa, or tomatoes the next
omatoes are succeeded by grasses or corn, but never by
. Peppers are often substituted for tomatoes on the heavier
weet potatoes are frequently succeeded by rye. Very often
tion consists of sod, corn with a cover crop, then strawberries
rs, or sweet potatoes two or three years. Root crops ordi-

phate. Tobacco is used as a fertilizer to a small extent in Atlan County. In some cases bone meal is used, both raw and steam On the bay shore of Cape May County the gathering of king horseshoe crabs for use as fertilizer material is an important ind try. The product is worth about $90 a ton, chiefly for the nitrog This material ought to be used in the county, but at present it shipped away. Cape May County in 1909 spent a total of $43, for fertilizer, which is an average of $84.83 for each of the 511 far using fertilizer. The average for Atlantic and Cumberland Count is somewhat higher. The price of manure ranges from $2 to $ ton. Poultry manure sells for 25 to 30 cents a bushel. At the pr ent time (1917) potash is very scarce and expensive, and the f tilizers contain from 1 to 3 and occasionally 5 per cent of nitrog and from 7 to 10 per cent of phosphoric acid. Applications lighter than formerly because of the much higher price.

The farm laborers are mainly white persons of foreign birth. present most of the work is done by the farmer and his fami Farm laborers receive $40 to $50 or more per month.

The table below gives some interesting data, taken from the 19 census, in regard to the comparative development of the th counties:

Number of farms and percentage of improved and unimproved land in far Atlantic, Cape May, and Cumberland Counties, 1910.

County.	Total farms.	Area in farms.		Improved land.		Per cent of im prov land
		In farms.	Per farm.	In farms.	Per farm.	

uy and get one-third the produce. In Cumberland and Cape
ounties the equal-share basis is the rule. Land rented for
corn often brings $5 an acre, and for sweet potatoes about

land in Cape May County sells for $15 to $100 an acre, de-
upon the location, the nearness to roads and railroads, and
nditions. Some farms have changed hands recently at $125
It Atlantic County farm values have been rather inflated in
ears. Uncleared land would probably average $15 to $20
and good farm land $100 an acre. Land in bearing peach
s brings a much higher figure. Farm values in Cumberland
are somewhat lower. Farms favorably situated, however, as
Vineland district, with a poultry plant and peach orchard,
$100 to $250 or more an acre. In more distant locations the
from $20 to $100. Uncleared land ranges from $6 to $20

ead irrigation by the Skinner system is practiced in many
f the area, especially in the northwestern part, and irriga-
nts are being extended steadily. Most of them are on the
as gravelly sandy loam, sand, and loamy sand. They cover
e-half acre to 6 acres or more. Plate VII, figure 1, shows one
arger plants. The source of water is either a stream or shal-
l, and gasoline pumps are used for raising the water. Two
crops are grown each year. They are put in as soon as the
can be prepared, lettuce as early as March 20. Irrigation
done at any time, but if begun in sunshine it must be con-
ntil the sun disappears. Some of the crop sequences on irri-
lots are as follows: Early peas or early Irish potatoes (Irish
) or strawberries are succeeded by late red-skin potatoes.

SOILS.

The Millville area lies within the Coastal Plain province extends as a narrow belt along the ocean from the south s Long Island to the Gulf of Mexico and the Rio Grande Ri gradually becomes wider to the southward, reaching a m width of about 200 miles. Soils of a sandy nature pred throughout the Coastal Plain region.

The soils of the Millville area are derived from uncons beds, mainly of marine origin. The chief formations are the sey sand,[1] which overlies practically the entire area, and southern and eastern parts the Cape May formation. Rem the Bridgeton terrace formation are local in extent, confined to the northern and western parts of the area. The Cohansey tion is composed of relatively coarse sand as compared to th lying Kirkwood and Cretaceous deposits that outcrop farthe north and west in the Camden, Salem, and Freehold areas further characterized by local beds of clay and gravel, th composed of quartz, chert, and quartzose-sandstone pebbles from one-fourth inch to 1½ inches in diameter. This is t extensive geological formation in the southern two-thirds or Plain region of New Jersey. The Bridgeton and Cape May tions, overlying the Cohansey sand, are largely of fluviatile and from the standpoint of soil-forming material do not di terially. They are composed essentially of gravel, sand, a beds of clay. The materials were derived in varying degr older formations, such as the Cohansey, Kirkwood, Cretace Triassic, and were laid down under varying degrees of subm er textured. These soils occupy well-drained, level to gently g areas and have a low to moderate content of organic matter. also are low in lime carbonate. The members of this series minate in the southern two-thirds of New Jersey. No types y important extent heavier than sandy loams occur in the ille area.

e Norfolk series has gray to light-gray surface soils and yellow le-yellow subsoils. In other characteristics its soils are quite r to the Sassafras series. In this area the Norfolk series is sented only by poorly drained phases.

se areas of the Cohansey sand which are practically free from material give rise to the Lakewood series, which has a white e soil and an orange, orange-yellow, or brownish-yellow sub- The topography ranges from level or gently rolling to rough ummocky, and drainage is always good or excessive. These re very low in organic matter, as well as in other elements ial to a productive soil.

Portsmouth series is characterized by a dark-gray to black e soil and a gray to white subsoil, often mottled with yellow. soils are developed in low areas at the heads of streams and nt to swamps, and the poor drainage accounts for the accumu- of organic matter and the resultant dark color. A gravel m is very often encountered in the lower subsoil.

St. Johns and Scranton series are closely related to the Ports- . The surface soils are similar, but in the types of the St. series a coffee-brown or black organic stratum resembling a an is encountered in the subsoil. The subsoil of the Scranton closely resembles the Norfolk in its yellow color. It fre- y shows mottlings of gray.

general distribution of soil textures in the area is shown in 2. Frequently one or more types are absent in the sequence; where the relief is gentle the Sassafras sandy loam or a similar ay take the place of the Sassafras sand, or, if the slope to the p is relatively steep, the belt of Portsmouth or similar soil e absent. In other places the Sassafras gravelly sandy loam e lacking.

ddition to the soils classed in the various series there are sev- ils of miscellaneous character. The wet, mucky areas through most of the streams flow are mapped as Swamp. Areas along ast subject to tidal action are mapped as Tidal marsh. Large of this land have been diked and are mapped as Reclaimed marsh. Narrow strips of Coastal beach have been mapped at s points along the shore.

the following pages the several soil types and phases are de- d in detail, and a general discussion of their agricultural re-

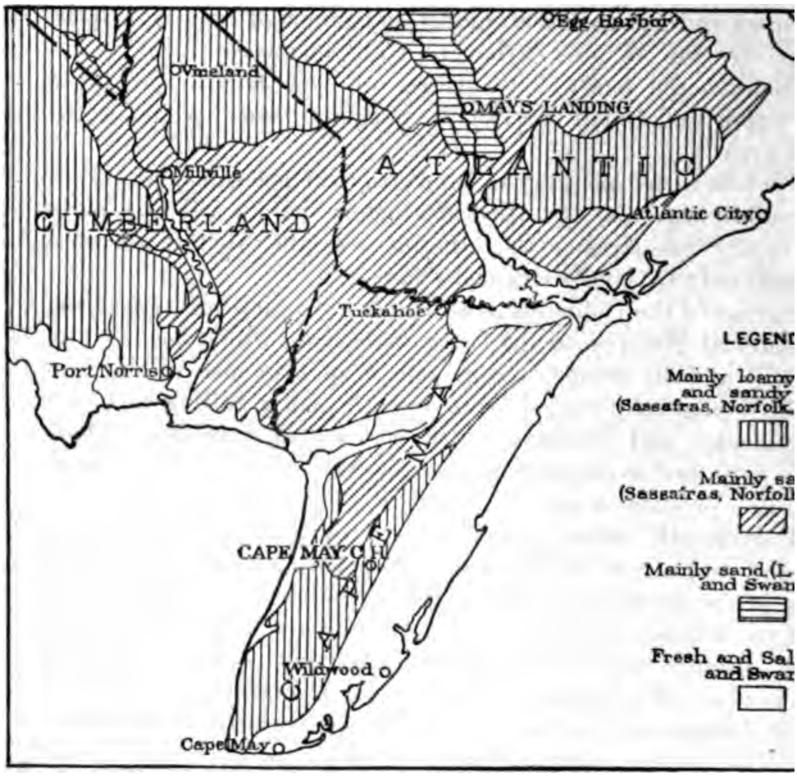


FIG. 2.—Sketch map showing distribution of soils by texture.

lationships is given. The table below gives the name and the

SASSAFRAS GRAVELLY SANDY LOAM.

rface soil of the Sassafras gravelly sandy loam, where developed, is a light-brown loamy sand to sandy loam, 6 s deep. The subsurface material is a yellow to yellowish- loam to heavy sandy loam, extending to a depth of 10 to Below this the subsoil is a reddish-yellow to dull-red, ıdy clay containing more gravel and coarse sand at depths 4 and 40 inches. Small to medium-sized white or yellow ıvel, about one-eighth to one-half inch or more in diameter, nt from the surface down through the entire 3-foot section, ıntent varies greatly.

pe is quite variable in texture. In the western and north- arts of the area it includes small developments of gravelly gravelly fine sandy loam. These occur most often in the ıg areas, as in the vicinity of Woodruff and Gouldtown. ıut the area there are included also patches of sandy loam, gravel makes up, perhaps, 10 per cent of the soil mass. e type occurs on the slopes of hills it often includes small gravelly coarse sandy loam, loamy coarse sand, and loamy e finer material having been washed away. There are also many areas, a few acres in size, of Sassafras sand and nd. In the wooded parts of the type the surface 2 to 6 gray or yellow rather than brown, as organic matter has ıe incorporated as in cultivated areas.

ıpping of this soil, and in fact of all the principal types, t in the wooded areas because of the prevailingly dense f underbrush, made up mainly of scrub oak. Where there ɔads, not as much detail has been shown as would otherwise ı possible.

ıssafras gravelly sandy loam has a general distribution ıt the area, and it is the predominant type in the north- ɪart. It occurs chiefly in the higher parts of the area, and ɔractically all of the Bridgeton and the higher parts of the y formation. It has the most rolling topography of any ped, although many areas are nearly level, as in the region Dennisville. The type has adequate surface drainage and inage, and some of the lighter textured areas at rather high s are excessively drained.

one of the most important types in the area. About 50 of it is cleared, a larger proportion than in the case of any ɪe. Almost all the important crops are grown more or less ly, with the exception of sweet potatoes, cantaloupes, and ons and several kinds of bramble berries, all of which are ainly on the lighter soils. Corn occupies a larger acreage

than any other crop. Rye is grown to an important extent. Pl
III shows a good growth of each of these crops. Much hay, chie
clover and timothy mixed, is grown. Other important crops are l
potatoes, of both white and red skin varieties, late tomatoes f
market and canning, strawberries, grapes, and peaches. Plate
shows a peach orchard on this soil. Many of the orchards in t
Vineland peach district are located on this soil, and it ranks as t
best peach soil in the area. Its slightly higher elevation and rolli
topography are favorable to peach culture, and it produces a healt
vigorous, long-lived, but not too rapidly growing, tree. Owing to
moderately heavy subsoil the trees are not pushed too rapidly in t
spring, and hence they are not as subject to frost as on the ligh
soils. They are naturally more productive, and less fertilization
necessary. Apples do very well and are a crop of growing imp
tance. In the Camden area to the north this is one of the most i
portant apple-producing types. Plate VII, figure 2, shows what c
be done with apples on this soil, and incidentally shows an imp
ment much used in orchard cultivation. Note the healthy and vig
ous appearance of the trees.

Crops of minor importance are asparagus, cabbage, turnips, swe
corn, onions, sweet potatoes, pole lima beans, market and canni
peas, rhubarb, pears, okra, horse beans, apples, and alfalfa. So
wheat is grown on this type in the northwestern part of the ar
There is a considerable acreage in French, cranberry, and bush li
(Fordhook) beans. A large acreage is devoted to peppers in t
vicinity of Vineland and east of that place. Near Vineland one fa
is devoted largely to dahlia production. Several farmers in t

ercial mixtures or manure, or both. The applications of fer- range from 300 to 1,600 pounds per acre. Fertilizers analyzing per cent nitrogen, 7 to 10 per cent phosphoric acid, and 8 to cent potash are generally used in normal times. At present. ittle potash being obtainable, the fertilizers generally analyze per cent of nitrogen and 8 to 10 of phosphoric acid, and carry ash.

n land of this type in favorable situations, with buildings, in price from $100 to $150 an acre, and in more remote locali- om $15 to $60 an acre. Uncleared land ranges from $6 to $25 e, depending upon the situation, the value of the timber, and e of the tract sold. It costs from $25 to $70 per acre to clear d. Some areas of this soil are very highly improved.

etimes in breaking more extensive areas large tractor-drawn are employed. The disks chop the small roots into short s and eliminate many of the smaller stumps. Deeper plowing give good results on this soil, and the depth should be in- d at the rate of, say, one-half inch a year for several years.

Sassafras gravelly sandy loam, like all the other soils of the s low in lime, as is indicated by the prevalence of hackberry, and similar growths, and since the maximum benefits from ation and green manuring depend upon the satisfying of the equirement this should receive greater attention. More lime cid phosphate, in connection with leguminous cover crops, be used to build up the soil. Even though many crops such wberries, raspberries, bush lima beans, and watermelons, do uire an alkaline soil, lime should be used for the benefit of the nanure crops. Until the soil has reached a fair degree of tiveness one cover crop supplemented with lime and acid phos- ought to be turned under for every money crop removed. The rades of fertilizer commonly used on this and other soils con- ore filler or worthless material than the higher grades, and ; economical. Home mixing should be practiced more widely. zers often are bought on credit and are said to cost at least 8 t more, when the money could be had in most cases for 6 per the local banks.

ose sections of the area where mosquitoes and flies are not too nt, especially in the northwestern part, more dairy stock be kept. In other sections hogs should be raised on a larger s they use the waste from truck crops economically. Along ore hog raising is even more strongly to be recommended, since e from the resorts is to be had in large quantities.

manure produced from the small number of animals kept is nomically used. Perhaps 50 per cent of its value is lost by leaving it piled up outside the stable door. It should be reenfor with acid phosphate and spread on the ground during the winter at least protected from the weather. Much of the value of the c fodder likewise is lost because it is permitted to remain out in weather in small shocks. It should be placed in large stacks near barn, or in the barn where possible.

More alfalfa ought to be grown on this soil. A good place to w the crop in would be after potatoes. More lime, at least 2 tons acre, should be applied in growing alfalfa, and the seed bed sho be worked down and rolled more thoroughly.

Considering the natural adaptation of this type to apples and demand for the product, both local and distant, it would seem t apple growing deserves more attention. Along the shore, especia the demand for early apples is never met. Yellow Transpar Williams Early Red, Duchess of Oldenburg, Summer Pearmain, Red Astrachan are the early varieties recommended, with the Davis, Stayman Winesap, Rome Beauty, Spitzenberg, McInt Red, and Wealthy as fillers. The Yellow Transparent has a te ency to blight, however, and the Spitzenberg should be limited the Sassafras gravelly sandy loam or similar soils, as it does not well on the lighter types. The Winesap and Williams Early Red very good varieties for this region. In intercropping it is prefer to use legumes or low-growing truck crops. Corn is not a desira crop to be grown in orchards on any of the soils.

Sassafras gravelly sandy loam, flat phase.—The flat phase diff from the typical Sassafras gravelly sandy loam in its nearly le surface, and in its frequently yellowish upper subsoil and moi lower subsoil. The latter becomes coarser and redder with de ften the lower portion of the 3-foot section consists largely of vel, but usually there is sufficient clay present to make the erent.

soil occurs mainly on slopes associated with the Sassafras ly sandy loam. Drainage is often excessive, and it is one of t soils to suffer from lack of rain.

is not an extensive type. The largest areas, which are un- l, occur northwest of Woodbine. There are a number of r patches scattered over the northern two-thirds of the survey. a small part of the type is farmed, but where it has been im- l it yields good crops of early vegetables, sweet potatoes, and fruits. Near Cedarville it is used successfully for onions. The rather leachy, however, and requires frequent additions of c matter.

SASSAFRAS LOAMY COARSE SAND.

Sassafras loamy coarse sand consists of a brownish loamy sand, 5 to 7 inches deep, over reddish-yellow loamy coarse sand rse sandy loam. In some places the subsoil below 30 inches is a orange-yellow, loamy coarse sand to coarse sandy loam. Often, the north-central part of the area, the soil contains numerous white and yellow quartz pebbles, and areas in which these are abundant on the surface are indicated on the map by gravel ls. Frequently there is a yellow subsurface stratum between 11 inches.

type as mapped is rather variable in texture and includes areas of Sassafras coarse sand, coarse sandy loam, and loamy Several large flat areas in the vicinity of Woodbine, in which wer subsoil is yellow and moist, are included. In the north- n corner of the area the type is mapped in a narrow sloping ying between Tidal marsh and the upland soils. Here small pebbles and oyster shells are quite abundant in the soil.

Sassafras loamy coarse sand is used principally in trucking. ading crops are beans, peppers, potatoes, onions, and sweet po- Some corn and hay are produced. It ranks as one the less tant types of the area.

SASSAFRAS SAND.

typical Sassafras sand consists of a light-brown or grayish- sand, underlain at 5 to 8 inches by orange-yellow sand, and to 30 inches by reddish-yellow sand which in most areas is ly loamy. Often the entire subsoil is reddish yellow. A gravel m is frequently encountered between 20 and 36 inches. The of this type, particularly the subsoil, is highly variable through- e area.

In some places the surface 1 to 3 inches consists of a clea
white sand passing abruptly into orange-yellow sand and
depths varying from 18 to 30 inches, into reddish-yellow
many places slightly loamy. In places the whitish surfac
underlain directly by reddish-yellow sand, but this appea
less frequently the case than in those areas where the surface
brownish-gray or light-brown sand. The white sand surfac
this variation is exactly like the Lakewood sand, and w
soil is deep enough to plow up gray and the areas are larg
to warrant separation, they are mapped as Lakewood. W
white soil is as deep as this the reddish-yellow subsoil ty
the Sassafras is rarely found. There are included in this
mapped some flat or low areas where the subsoil shows no
yellow, such areas representing the Norfolk sand. Even
the higher areas show none of the typical reddish yellow, bu
the lower subsoil is orange yellow, and not pale yellow
Norfolk sand subsoil. The included depressions are frequent
in the lower subsoil.

Areas which have a scattering of small quartz gravel on
face are indicated on the map by gravel symbols. Frequen
areas of Sassafras gravelly sandy loam are thus shown. G
these latter areas are characterized by a slightly loamy su
sembling the Sassafras loamy sand, but in many cases no d
in texture can be noted. Where the type approaches a coa
small gravel is frequently present throughout the 3-foot se

There also are included some small areas, as 1 mile
Hunters Mill, 2 miles west of Mays Landing, and elsewh
deep variation of the Sassafras sandy loam, which consists

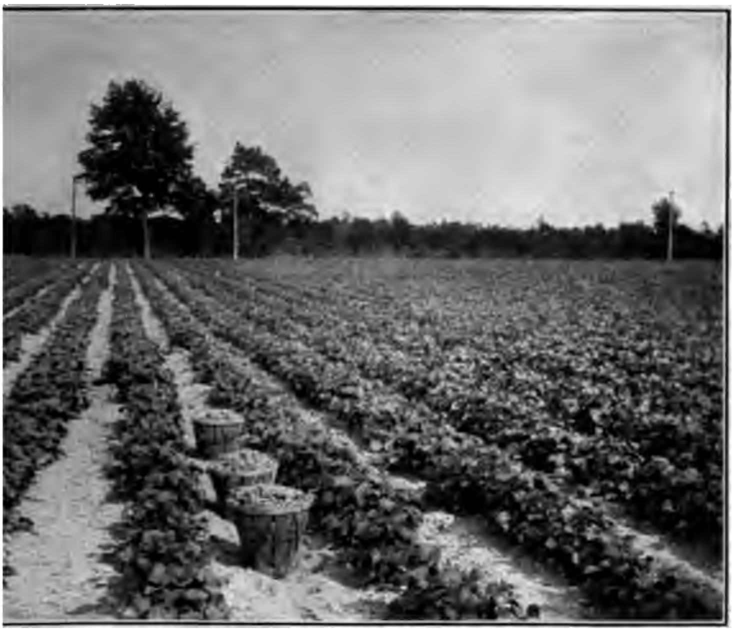


FIG. 1.—STRING BEANS ON SASSAFRAS LOAMY SAND.

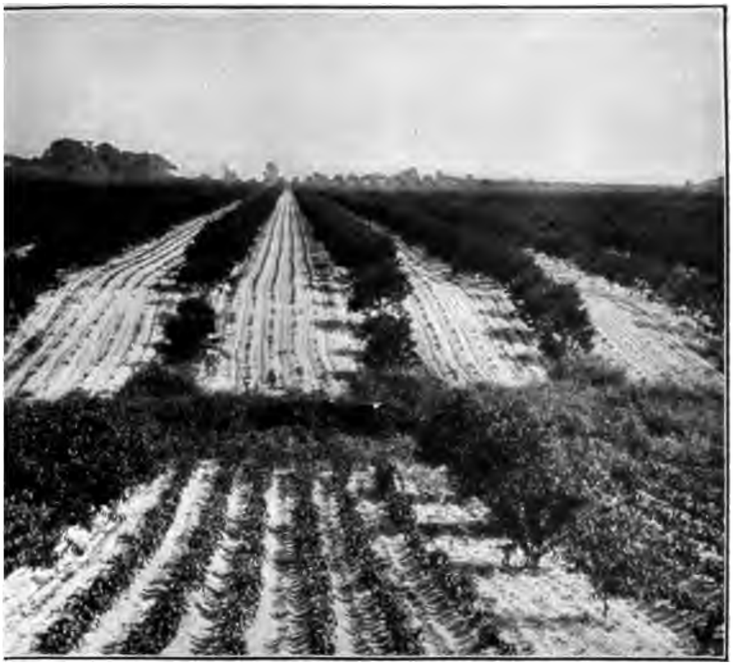


FIG. 2.—PEACHES ON SASSAFRAS GRAVELLY SANDY LOAM.

graphy, which is that of the more rolling areas of the northwestern part of the survey; also the healthy tree growth. The interplanted crop is peppers.

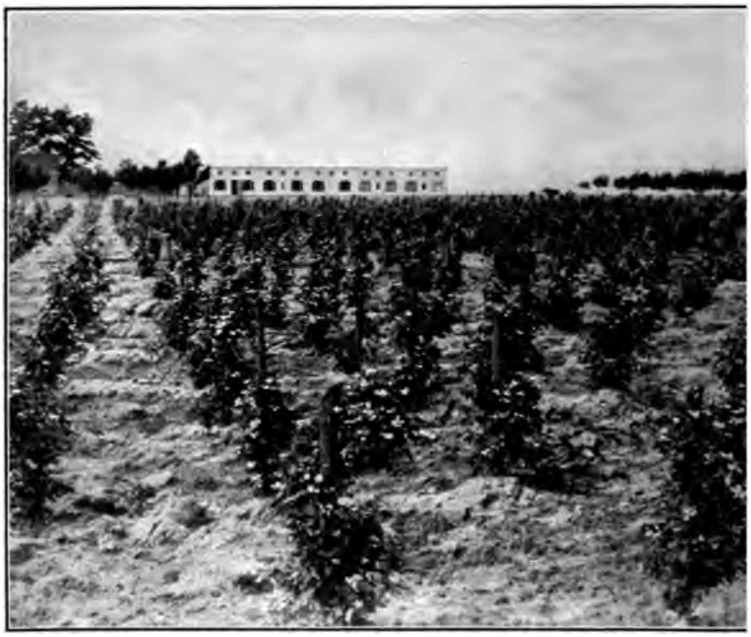
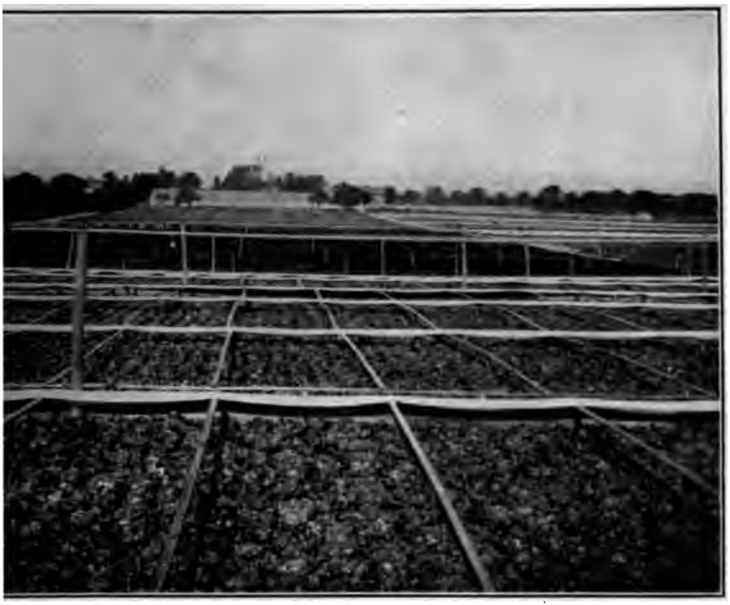


FIG. 1.—A FIELD OF BLACKBERRIES.

The soil is Scranton sandy loam in foreground and Sassafras loamy sand in backgro



INNER SYSTEM OF IRRIGATION ON SASSAFRAS GRAVELLY SANDY LOAM.

Lettuce in foreground, strawberries and other crops in background.

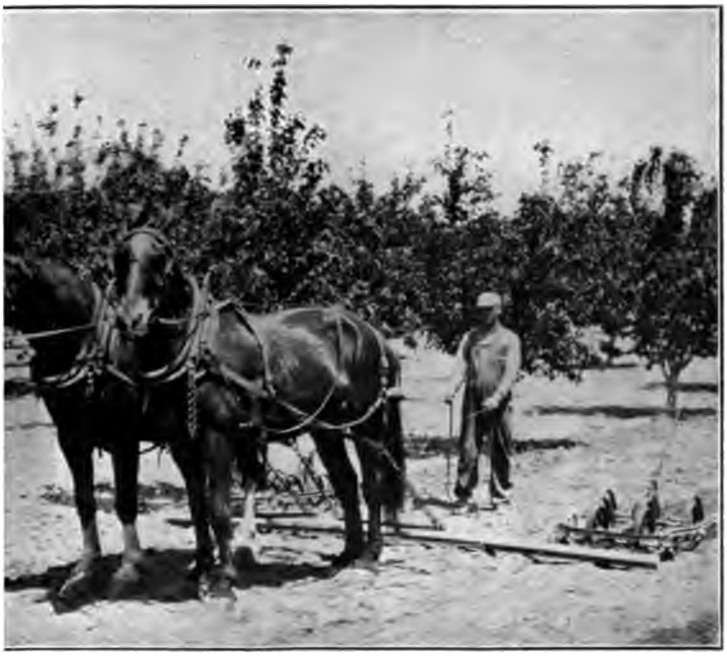
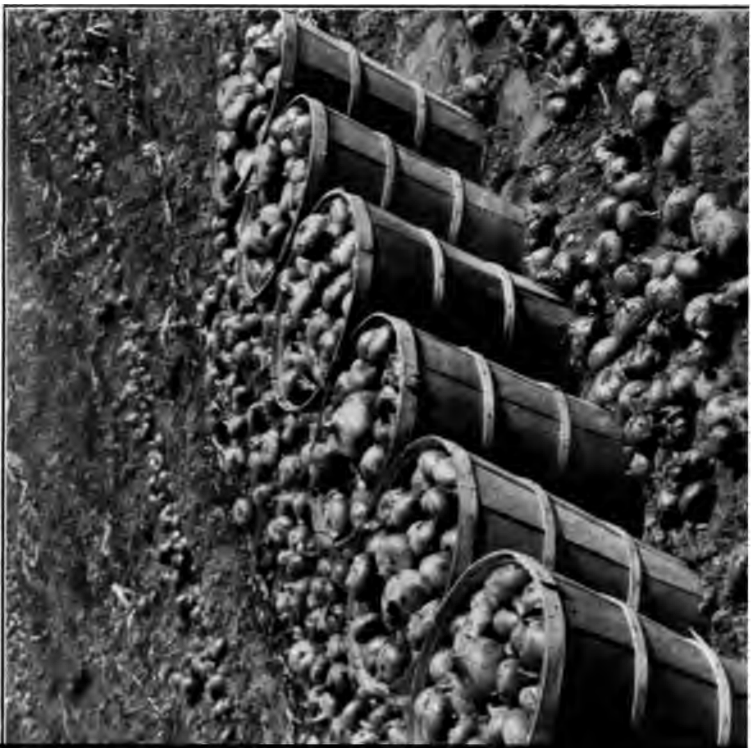


FIG. 2.—APPLES ON SASSAFRAS GRAVELLY SANDY LOAM.

Small horses are not needed when this tool is used.



settled region of the area. The timber growth is similar to
the Sassafras gravelly sandy loam, except that the proportion
is probably greater.

type is commonly referred to as a "sweet-potato soil." It is
r all the upland crops, among which corn and hay are im-
, but especially for early truck crops such as potatoes, to-
sweet corn, green peas, and onions. The bulk of the sweet-
rop of the entire Millville area is produced on this soil. Dew-
are grown extensively on this type in Cumberland County,
h dewberries and raspberries in Atlantic County. Water-
and cantaloupes are grown more or less extensively in some
, as along the Maurice River. There are some good stands of
on this soil.

s of practically all crops are somewhat lower than on the
as gravelly sandy loam and sandy loam, and the type in
has a lower selling value. It requires more organic matter
avier fertilization than the sandy loam, and owing to its
nature the effect of commercial fertilizer soon disappears.
f the crops give as good yields as on the heavier members of
safras series, although the crops most extensively grown are
st suited to the type. This soil should not be allowed to go
the winter without a cover crop of rye and vetch or clover.
produce a good growth of rye.

fras sand, flat phase.—The Sassafras sand, flat phase, con-
a light-brown or brownish-gray sand passing at 6 to 8 inches
llow sand and this at 18 to 24 inches into reddish-yellow,
loamy sand. The latter gives way to yellow or pale-yellow
about 30 inches. In many places, however, the upper subsoil
sh yellow to a depth of only 20 inches, where pale-yellow,
d is encountered. A stratum of gravel is of common occur-
t 20 to 36 inches. The very low areas have a yellow subsoil
out, and if they were of sufficient size they would be mapped
olk sand. Small areas of other types are included, such as the
as sandy loam, loamy sand, and sand.

phase occurs closely associated with the Sassafras sandy loam,
se. It is used for much the same crops as the typical Sassa-
d. Strawberries are grown more extensively. Late tomatoes
e lima beans are important crops along the north shore of
re Bay. A considerable proportion of the phase is cleared
ler cultivation, but part of it is not adequately drained.

fras sand, mixed phase.—The Sassafras sand, mixed phase,
ginally mapped as Norfolk sand, but owing to its extreme
uniformity it has been thought best to class it as a mixed
f the Sassafras sand. It includes patchy areas of (1) Sassa-

fras sand with a grayish-brown surface soil to a depth of 6 or 7 inc overlying reddish-yellow sand throughout the 3-foot section; (2) N folk sand, with a light-gray to whitish surface soil and a pale-yell subsoil; and (3) an intermediate soil between the Sassafras and N folk sands which has a grayish to whitish surface soil in the forest areas and a grayish-brown soil in the cleared areas. The upper s soil is like that of the Sassafras sand in being reddish yellow orange yellow, and the lower subsoil pale yellow like the Norfo In addition there are included areas with a rather loamy subs some small areas having a reddish-yellow sandy loam to sandy c subsoil, small areas of Lakewood sand, and in the northeastern p tion of the area several areas of Sassafras sand, flat phase, wh are moist in the lower subsoil.

The surface of the Sassafras sand, mixed phase, is usually flat gently rolling, but the drainage is good, and noticeably better th on the flat phase. The mixed phase occurs chiefly in the northeast part of the area, where it is associated with the typical Sassaf sand and with the gravelly sandy loam. Its lighter color indica that oxidation has not proceeded as far as in the typical Sassaf sand, and the phase is not as productive, although in general its and adaptations are similar. It lies mainly in Atlantic County, a large areas of it belong to the county, which according to law m purchase all lands sold for taxes where the proceeds do not cover three years taxes due, plus the cost of sale.

SASSAFRAS LOAMY SAND.

The typical Sassafras loamy sand consists of a brownish-gray sa

r sweet potatoes, of which it gives somewhat larger
e Sassafras sand. Probably one-fifth of the type is
ion.

amy sand, flat phase.—The Sassafras loamy sand, flat
s of a brownish-gray sand or slightly loamy sand,
s deep, overlying yellow sand to loamy sand which
26 inches into reddish-yellow loamy sand. The lower
foot section has a pale-yellow color and is wet. Often
soil continues reddish yellow, as in that part of the
f Newport. There are included with this phase small
ifras sandy loam, flat phase, and Sassafras sand, flat
pography is level and drainage is not always adequate,
ost cases sufficient for crop production. In its crop use
ent this soil is very similar to the flat phase of the
l. Perhaps 35 to 45 per cent of its area is cleared.

SASSAFRAS COARSE SANDY LOAM.

as coarse sandy loam consists of a brown to grayish-
sandy loam to loamy coarse sand, underlain at 5 or 6
owish to reddish-yellow coarse sandy loam and at 8 to
eddish-yellow to dull-red or yellowish-red coarse sandy
here is much gravel and sand in the lower subsoil.
s found in small areas associated with the other Sassa-
efly in the northern half of the area. It occurs largely
fering in this respect from the Sassafras sandy loam.
nges from sloping to level.
od soil, but it is hardly as productive as the sandy loam.
much the same crops as the Sassafras gravelly sandy
ly loam. It is not extensive and only a small acreage is
ion.

SASSAFRAS SANDY LOAM.

ras sandy loam consists of a light-brown or grayish-
sand to sandy loam underlain at 6 to 8 inches either by
friable sandy clay, or by yellow heavy sandy loam
into yellowish-red friable sandy clay. The lower part
section is always coarser textured and more friable.
e upper subsoil is yellow or orange yellow, especially
nd flatter areas, but there is always a distinct reddish
wer subsoil, and in places it is dull red. In forested
quently elsewhere the surface inch or two is light gray
mbling the Lakewood sand, but brown Sassafras mate-
ntered beneath this surface layer. Small gravel and
e nearly always found between depths of about 28 to 40

inches, this part of the 3-foot profile consisting of loamy s gravelly or coarse sandy loam.

This type in some respects resembles the Ruston sandy lo extensive soil of the southern Coastal Plain, but it differs ma in its browner soil and looser textured lower subsoil. Variation typical occur at a number of places. In the vicinity of B Point there are included areas having a lighter textured surfa and a typical subsoil, and vice versa. Some areas on the lowe of the Cape May Peninsula and in the vicinity of Newport La run light in texture throughout the soil section, approaching a sand. Included with the type are many small areas of nearly other Sassafras soils, chiefly the coarse sandy loam, loamy loamy coarse sand, and gravelly sandy loam.

There are also included several areas of Sassafras loam an sandy loam, the former occurring one-fourth mile south of Wo and three-fourths of a mile northwest of that place. These so more productive than the sandy loam. They consist of abo inches of brown loam over reddish-yellow sandy clay or clay At 24 inches a gravel stratum is encountered. The fine sand areas are found 2 to 3 miles west of Mays Landing and con about 7 inches of brownish-gray fine sandy loam to loamy fin over yellowish to reddish-yellow fine sandy clay to clay. In places these areas are really the Norfolk fine sandy loam.

The Sassafras sandy loam occurs throughout the area, usu the lower situations, associated with the Sassafras gravelly loam, sand, and loamy sand. It is most extensive in the southw part of the area and on the Cape May Peninsula. Its surface i or only gently rolling, but the drainage is good.

il is dark gray to black there is included some Ports-
ìcranton sandy loam. Much of the soil as mapped is
lk loamy sand, poorly drained phase, which it is not
parate because of the variability in texture.

grown on this soil are very similar to those on the Nor-
am, poorly drained phase. In seasons of plentiful rain-
e drainage is deficient corn often turns yellow.

NORFOLK SANDY LOAM, POORLY DRAINED PHASE.

ɔe 3 to 5 inches of the Norfolk sandy loam, poorly
e, is a brownish-gray loamy sand to sandy loam. This
·yellow sandy loam which passes at 10 to 20 inches into
heavy sandy loam or sandy clay. Mottling is usually
e lower part of the 3-foot section.

s quite variable in color and texture. In the less de-
ꞩ the subsoil below 15 inches contains considerable red,
ıs are not extensive. In the vicinity of Newport and 5
f Mays Landing, the surface soil is a rather dark-brown
ınderlain by a yellow, heavy sandy loam to sandy clay.
24 inches the material is always moist or even wet, and
ımonly encountered in the lower subsoil. Occasionally
stiff, yellowish clay to sandy clay is found, which be-
r colored and coarser in texture with depth, the soil in
ˑesembling the Sassafras soils. In the forested part of
not uncommon to find an inch of black, mucky soil over-
s of grayish-brown to brownish-gray sandy loam. This
.derlain by 6 to 30 inches of the typical yellow to pale-
ʀ loam or sandy clay. Below 30 inches in the higher

surface portion or as yellow in the subsoil as the present type ever, and it was not as poorly drained.

The Norfolk sandy loam, poorly drained phase, occupies lo depressed areas adjacent to and at the heads of streams and sw often occupying the normal position of the Portsmouth although it naturally lies at a higher elevation than the There are rather large bodies adjacent to the Tidal marsh southern and southwestern parts of the area, and it is these th chiefly farmed. The surface is level, and artificial drainage is sary to produce the best results. The soil is used for corn, ha lima beans, and other vegetables, as well as strawberries. Yie good when the season is not too wet. The forest growth on this abundant and includes, in addition to the trees on the Sa gravelly sandy loam, a number of swamp species.

LAKEWOOD SAND.

Typically the soil of the Lakewood sand is a white, loose sand, 6 to 20 inches deep, with perhaps an average depth of 1 inches. This overlies either orange-yellow sand or brownish sand which passes below into orange-yellow sand.

This brownish-yellow subsurface stratum represents an ap to the Leon sand. In the lower situations it is developed as a brown, organic, somewhat compact layer, such areas represent Leon sand as mapped extensively in Georgia and Florida. compact layer varies from 3 to 8 inches in thickness and is e tered at depths of 10 to 30 inches.

There are included with the type some developments of t [redacted] is usually excessive, and in dry weather vegetation suffers : of moisture.

›e is not extensive, and practically none of it is cultivated, ɜ some moderately successful vineyards and patches of ›erries, but the soil is so leachy and so low in humus and lant food that the expense of improving it to the point of ɜ fertility would be disproportionate to the returns.

PORTSMOUTH SANDY LOAM.

rtsmouth sandy loam typically consists of 4 to 10 inches of ' loamy sand to black mucky sand, overlying whitish or ·hite and yellow sandy loam to sandy clay. In some places subsoil is a light-gray or white sand or loamy sand passing nto a white and yellow mottled sandy loam to sandy clay. luded areas, such as that 1 mile south of Buckshutem, have re of a loam, with a correspondingly heavy subsoil. This eared and ditched and gives excellent yields of hay, corn, vegetables. In places it shows an organic hardpan layer ɔ that of the Leon soils. Another area of this included is recognized 4 miles southeast of Dennisville, bordering nd Beaver Swamp.

ıre also included some small areas of Elkton gravelly loam, l sandy loam, which are gray in the surface portion and y in the subsoil, and mottled with yellow. Gravel is often ·ed in these areas at about 30 inches. They occur in the art of the area in the vicinity of Gouldtown, Woodruff, and e. One of them occupies a rather large depression 2½ miles Centerton. The Elkton soils, like the Portsmouth, are flat .y drained, and the small fields that are cleared are used for crops as the Portsmouth sandy loam.

ɔrtsmouth sandy loam as mapped includes small areas of dy loam, which differs in having a highly organic, compact ɜmbling a hardpan in the subsoil. One-half mile south of there is included a small area of Portsmouth silt loam. the areas are variable, and many of the borings show Scran- ɾ loam, but the areas are mapped as Portsmouth where the ms to be the predominating soil.

·rtsmouth sandy loam is an extensive type. It lies adjacent ›s, and often as a belt between Tidal marsh and the upland ts surface is level and it is poorly drained, but a gravel hat is usually present in the lower subsoil aids the internal t of water. Artificial drainage is effected by means of open ·ractically no tile being used.

very small part of this soil is cleared. The timber growth ınt, including much or all of the upland vegetation and in addition many of the swamp species. Wintergreen or te always abundant on this and similar soils. The type is us for the production of hay, of which it gives splendid yi limed and manured, and corn, tomatoes, peppers, potatoes, strawberries are also grown extensively. The type prod yields of strawberries of good quality.

This soil has considerable agricultural possibilities, and be more generally used for crops not grown for seed. D the essential in its improvement, and this should be acc with tile drains, the open ditches now used having been f unsatisfactory. If the type were properly drained alfalfa grown over much of its area.

SCRANTON SANDY LOAM.

The Scranton sandy loam consists of a dark-gray to bla sand or sandy loam underlain at 6 to 10 inches by a pale-yell loam which passes below into yellow sandy clay. Frequ moist or wet lower subsoil shows some gray mottling. Wh joins the Sassafras soils, the type resembles the soils of tha its subsoil, but where typical the surface soil is like that of mouth sandy loam and the subsoil much like that of th sandy loam, poorly drained phase. In most places a grav is present in the subsoil below a depth of 16 to 20 inches.

The Scranton sandy loam is much less extensive than t mouth sandy loam. The largest areas are mapped in the v Marshallville and Risleyville.

The type is somewhat more productive than the Portsmo loam, but not much of it is farmed.

ST. JOHNS SAND.

r yellow. The material below the hardpan is more fre- le yellow than white. In places it is orange yellow.

:e included with the St. Johns sand, as mapped in this l areas of Swamp, Leon sand, Portsmouth sandy loam, sand, and Norfolk sand and sandy loam, imperfectly .ases.

Johns sand occurs in level or depressed, narrow belts ad- nd at the head of swamps. The drainage is poor, and not e type is farmed. Artificial drainage would be somewhat iere the hardpan is well developed, as it interferes with ternal movement of water whether the latter is moving e of gravity or by capillary attraction. The type is not ive as the Portsmouth sandy loam, although in many surface material is similar, both soils having sufficient or- er to make them quite loamy. The forest growth is very that on the Portsmouth sandy loam, and the type has same place in the agriculture of the area.

SWAMP.

classed as Swamp occupies low, wet areas along streams wet flats about stream heads. The soil is highly variable. chiefly of black mucky sand, loamy sand, sandy loam, or 3 feet deep, overlying white or yellowish sand or dark- d or sandy loam. This material was mapped as Hyde l in the Camden area, but because of its highly variable is classed as Swamp in this survey. Occasionally the eas are full of small islands. This is particularly true of np between Cedarville and Dividing Creek. These islands :d 2 to 3 feet above the general surface and consist of h sand and sandy loam, Elkton loam (in Bear Swamp), lk sandy loam, poorly drained phase. The soil in Bear not very wet except in rainy seasons, and the growth is ech. Of less importance are Carolina red maple, sweet gum, white cedar, and holly. The most valuable of the Swamp are the "cedar swamps" or "cedar brakes." in most striking growth is white cedar. Good cedar-swamp g $200 to $400 an acre for the timber. Other species in abundance are sweet bay or swamp magnolia, Carolina , sweet pepperbush, sour gum, marsh alder. Among the ints blueberry, sumac, azalea, and ferns are abundant. In iere are many grasses, mosses, rushes, and sedges.

is one of the most extensive types mapped in the Millville t is of little agricultural importance. It is used only for :tion of cranberries, a small acreage having been drained and converted into cranberry bogs. Where the Swamp

adjoins Tidal marsh it is not always easy to determine t
which therefore is drawn more or less arbitrarily in pl

TIDAL MARSH.

Tidal marsh consists typically of bluish or mottled
reddish-brown, and bluish-gray silty clay loam, ov
bluish-gray silty clay loam or silty clay which contains
places. In some places the material consists of a br
brown or nearly black sand, sandy loam, or loam ove
clay or silty clay loam. There is always present in the
abundance of plant roots and partly decomposed vege
and occasionally the upper soil consists largely of thi
terial. The subsoil is charged with hydrogen sulphide.

This is one of the most extensive soils in the area.
more or less continuous belt 3 to 5 miles wide along t
east boundary of the area, and extends up the main riv
siderable distance.

The only agricultural product taken from this soil i
Probably 10,000 to 12,000 acres or more are cut over
this hay. Where the land is dry enough to support m
grass is cut in summer; from the remainder the crop is
the winter when the ground is frozen. If cut before it
hay is of better quality, and is used for feeding horses
grades of hay bring $5 to $6 a ton locally, and $8 to
distant markets. Many "meadows" are ditched and the
vided with flood gates. When it is desired to flood o
land these gates are opened so that the tidewater may c

In mapping Tidal marsh a distinction has been made

is made to farm the land for two or three years after diking.
d is used chiefly for hay, corn, oats, strawberries, late pota-
d tomatoes. Alfalfa is grown successfully in Cumberland
. Not much fertilizer is used, but some farmers use lime at
of 50 bushels per acre every four years. Acreage yields of 3
more of hay or 100 bushels of corn are not uncommon.
rries yield abundantly.

COASTAL BEACH.

s mapped as Coastal beach consist of whitish to yellowish fine
sand, with a high content of black sand in places. They oc-
he barren, wave-washed beaches and a higher adjoining strip
which some vegetation has established itself. Here myrtle,
r, and beach grasses grow, with some pitch pine, red cedar,
s oaks, wild cherry, sumac, red maple, and holly. The type is
tensive, and it is of little importance agriculturally. It is used
all way for garden truck. The surface is rather hummocky in

MADELAND AND CLAY PITS.

he areas mapped as Madeland and clay pits the soil has been
in by artificial means or has been mined for industrial pur-
In most places the soil of the filled areas consists of sand and
h deposited by hydraulic dredges. Madeland proper occurs
along the shore, at points where it has been desired to extend
ce town sites.

SUMMARY.

Millville area comprises the most southerly part of New
. It covers all of Cape May County, the eastern three-fourths
mberland County, and the southern two-thirds of Atlantic
y.

area has no striking physiographic features. It is mainly
out in places rolling. The general slope is to the south and
nd the range in elevation is from sea level to 141 feet above.
ware Bay receives the drainage from the western half of the
nd the Atlantic Ocean that from the eastern half. The two
ge basins are separated by a broad but not well marked ridge.
rincipal streams of the Delaware Bay watershed are the
ce River, Dividing Creek, and Dennis Creek. The Tuckahoe
reat Egg Rivers, and the Mullica River lying outside the area
ed, drain the Atlantic watershed.

the rivers are tidewater streams for 5 to 15 miles from their
s, and their tributaries, which penetrate all parts of the area,
heir sources in or flow more or less sluggishly through low,

swampy areas. The upland, however, is for the most pa drained except in a broad belt adjacent to Tidal marsh north o ware Bay, where drainage is only moderately well developed.

Settlements in this region date back to the early part seventeenth century. From one-half to three-fourths of the lation is native stock. The foreign population consists chi Italian, Russian, Irish, German, or English people. The a number of rural inhabitants per square mile ranges from 2 Atlantic County to 46.4 in Cumberland County and 74.5 in May County.

The chief coast towns are Atlantic City, Ocean City, May City, and Wildwood. The most important inland tow Millville, Vineland, Egg Harbor, Cape May Court House, Landing, and Port Norris.

Railroads reach nearly every part of the area, and graveled well graded and well kept, reach all the farming sections.

The principal outside markets are New York and Philad Much produce is sold in the shore cities and in the local m There are a large number of canning factories in the area, and take much produce.

The climate is mild and characterized by a generally high h ity, which at times makes the cold in winter penetrating and th in summer oppressive. The growing season averages 200 da length.

Prior to 1880 general farming predominated in this region with the growth of the large centers of population, such as Phil phia and New York, and the development of numerous resort t

Insects and diseases are kept well under control by modern s such as spraying. Level cultivation is the rule for most The farm equipment, including houses and barns, while not e is well suited to the needs of the farmers.

me sections no crop rotations are followed, in others only rotations. Continuous cropping, especially of sweet potatoes, r the rule. Cover crops are used widely. They consist chiefly on clover, rye, and vetch.

lizers are used for nearly all crops, in applications ranging 0 to 1,600 pounds per acre. Potatoes receive the heaviest tions. The fertilizers in normal times run from 2 to 4 per nitrogen content, from 8 to 10 per cent of phosphoric acid, to 10 per cent of potash. Much low-grade fertilizer is used, ng only 1.5 or 2 per cent of nitrogen. Stable manure and manure, fish scrap, and bone are widely used.

farms are for the most part small. They are largest in Cape ounty, averaging 66.6 acres, and smallest in Atlantic County, ng 46.4 acres.

ns are generally rented on an equal-share basis, although in ic County many farmers pay a cash rent. The number of operators is unusually high.

average price of farm land is in the neighborhood of $50 an nd of uncleared land about $20 an acre. The range for the r is from $20 to $250, and for the latter from $6 to $40. In ic County the prices of uncleared land are higher than else-

m four-fifths to five-sixths of the area is uncleared. In the ed regions the growth consists mainly of huckleberry, pitch and various oaks, often of bushy or only medium growth.

Millville area lies wholly within the Coastal Plain province, he soils have all been derived from unconsolidated material. geologic formations give rise to the soils, the most important ich is the Cohansey sand, followed by the Bridgeton and Cape errace formations.

series of soils are identified in the Millville area, the Sassa- Norfolk, Portsmouth, Scranton, St. Johns, and Lakewood. st four are each represented by one type.

Sassafras series is made up of well-drained types with or grayish-brown surface soils and reddish-yellow subsoils. ravelly sandy loam, sandy loam, and coarse sandy loam are or medium to late truck crops, corn, hay, and tree fruits. The r members, the sand, coarse sand, loamy sand, and loamy coarse are used largely for early truck, small fruits, sweet potatoes, eaches.

The Norfolk soils are gray to brownish-gray, with yellow yellow subsoils. A large proportion of the sandy loa drained phase, is farmed, but comparatively little of the san drained phase. These soils are used for hay, corn, late tru and strawberries.

The Portsmouth sandy loam is largely uncleared. The su of this type is dark-gray to black, and the subsoil is white t often mottled with yellow. Drainage is poor. Hay, corn, l and strawberries are grown.

The Scranton sandy loam has the same character of su as the Portsmouth, but the subsoil is yellow or pale yell type is largely uncleared. Its agricultural use is similar t the Portsmouth sandy loam.

The St. Johns sand has a dark-gray to black surface s white to yellowish subsoil. It differs from the Portsmouth i at varying depths a coffee-brown, compact layer of sand, re a hardpan, which contains more or less organic matter. is not as productive as the Portsmouth sandy loam, and not it is farmed. It is poorly drained.

The Lakewood sand is white to a depth of 14 or 20 in below this orange to reddish yellow. This soil is excessivel for the most part, and it is not productive. Practically no farmed.

Tidal marsh is an extensive soil forming a more or less c belt around the south and east boundary of the area. Muc cut over for "salt grass," and no other use is made of the part lying mainly along streams is overflowed by fresh wate marsh of this sort has been reclaimed by diking.

DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

Bulletin 727

POTASH IN THE GREENSANDS OF NEW JERSEY

BY

GEORGE ROGERS MANSFIELD

Work done in cooperation with the Department of Conservation
and Development of New Jersey

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

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ABSTRACT OF REPORT.

The greensand marl belt of New Jersey extends across the State from the vicinity of Sandy Hook at the northeast to Delaware River near Salem at the southwest, a distance of about 100 miles. It is crossed at many places by railroads and by streams that flow into Delaware River.

The potash in the greensand marl occurs chiefly in the mineral glauconite, which is essentially a hydrous silicate of ferric iron and potassium. Nearly all the Cretaceous formations contain glauconite, but only three contain sufficient amounts to be considered commercially important, though in some others it is locally abundant. These three are the Navesink (the lowermost), Hornerstown, and Manasquan marls, which are described respectively as 25 to 40, 30, and 25 feet thick. The marl beds, which form part of the Coastal Plain strata, strike about N. 55° E. and dip about 33 feet to the mile southeast, but there are some variations. The gently inclined and poorly consolidated beds that compose the marl are beveled by erosion and covered to a greater or less extent by later deposits.

Five type areas were explored by borings and made the basis of specific estimates. These were at Salem and Woodstown, in Salem County; Sewell, in Gloucester County; Somerdale, in Camden County; and Elmwood Road, in Burlington County. The data gathered from borings were supplemented by well data, both published and unpublished, and by field data on file in the office of the State department of conservation and development.

It is conservatively estimated that the New Jersey greensands contain 256,953,000 short tons of potash (K_2O) that could be mined by open-pit methods. At the rate of importation for the five years preceding the World War, including 1914, this quantity could supply the needs of the United States for nearly 1,000 years. Should it ever become practicable to use underground methods of mining, the available quantity of potash would be enormously increased.

The lime sand in probable commercial thickness is exposed or has been recognized in wells as far north as Wrightstown.

Four companies have undertaken to produce or utilize the potash from New Jersey greensand. Small quantities of potash have been produced and marketed by some of these companies, but none are now producing. The potash industry of the United States was dealt a

severe blow by the conditions arising after the armistice was declared. It seems probable, however, that some of the large developments will survive. Whether or not greensand may have a place in the American potash industry will depend on how well the greensand operators may be able to compete not only with German producers but also with American producers of potash from other sources.

Recent experiments indicate that the potash in greensand is promptly available to meet the needs of many and perhaps most farm crops.

Composite samples, so prepared as to represent the principal beds of commercial thickness at each of the localities drilled, were washed and the residues magnetically separated and sized. A variety of determinations upon original or prepared samples were also made in the chemical laboratory of the United States Geological Survey. The results of these separations and determinations are discussed both in their relation to the recovery of potash from greensand and in their bearing on the origin of glauconite.

OTASH IN THE GREENSANDS OF NEW JERSEY.

By George Rogers Mansfield.

INTRODUCTION.

PURPOSE AND SCOPE OF INVESTIGATION.

The work on which this report is based was begun in the fall of 918 as a part of the systematic search for potash conducted by the nited States Geological Survey since 1910.

The New Jersey greensand marls have long been known to contain nall amounts of potash, lime, and phosphate. For more than 100 ears they were dug and marketed as fertilizer, and in the late sixties e annual amount so used aggregated nearly 1,000,000 tons.[1] With e introduction of prepared fertilizers the marl industry died away, ut small amounts of greensand are still dug and used here and there.

It has been considered impracticable to extract commercially e potash from greensand because of the relatively insoluble charcter of the mineral in which the potash is locked up. Of late years, owever, there has been considerable experimentation in processes f extracting potash from silicate minerals, and the New Jersey reensands, which are silicates, have attracted attention because f their accessibility, abundance, and relative ease of mining. The carcity of potash resulting from the shutting out of German supplies uring the World War gave impetus to these experiments and ermitted hope of the establishment of a potash industry in the Inited States in which the New Jersey greensands might be an nportant factor.

Much general information about the greensands was available hrough the published reports of the Geological Survey of New ersey and of the United States Geological Survey and from other ources. The greensand beds had been mapped and described in onsiderable detail. There was, however, little specific knowledge egarding the quantity, thickness, and character of the deposit nd the accompanying overburden at any particular place. The urpose of the work, therefore, was to procure data sufficient to ermit estimates of the tonnage of potash in certain areas that are and assumed the other expenses incidental to the preparat publication of the report.

---

[1] Cook, G. H., Geology of New Jersey, p. 461, 1868.

ACKNOWLEDGMENTS.

The writer desires to express his thanks to Dr. Henry B. K State geologist, and his staff for much helpful information the use of unpublished data, including field notes, manuscrip and well records. Several days were spent at his office in th of this material. Dr. Kümmel accompanied the writer on trips to different parts of the marl belt, one of which was mac ble by the kindness of Prof. Gilbert Van Ingen, of Princeton sity, who gave his time and the use of his automobile. Dr Twitchell, assistant State geologist, went over some 500 (search of analyses that might bear on potash exploration, out numerous well records, and kindly permitted the us unpublished manuscript on the water resources of the State.

The numerous analyses embodied in this report were mad laboratories of the Geological Survey, mostly by R. K. though some were made by Chase Palmer and E. T. Erickson. Steiger, chief chemist, made many helpful suggestions, an Hicks, of the laboratory staff, visited parts of the field v writer. E. S. Larsen, jr., examined a number of thin secti made helpful suggestions. Hoyt S. Gale, geologist in ch the potash investigations of the Survey, Mr. Hicks, and Mi Nourse have contributed valuable suggestions and criticism

The writer is indebted to the following persons for permi drill on their land: Messrs. Louis A. Fogg, T. R. Miller, and Hires, of Salem; Mr. Isaac K. Lippincott, of Woodstown; M Voorhies, of Woodbury, secretary of the West Jersey Marl & portation Co. (owner of property at Sewell); Mr. Thomas Mc of Somerdale (Laurel Springs post office); Mr. Alfonso F

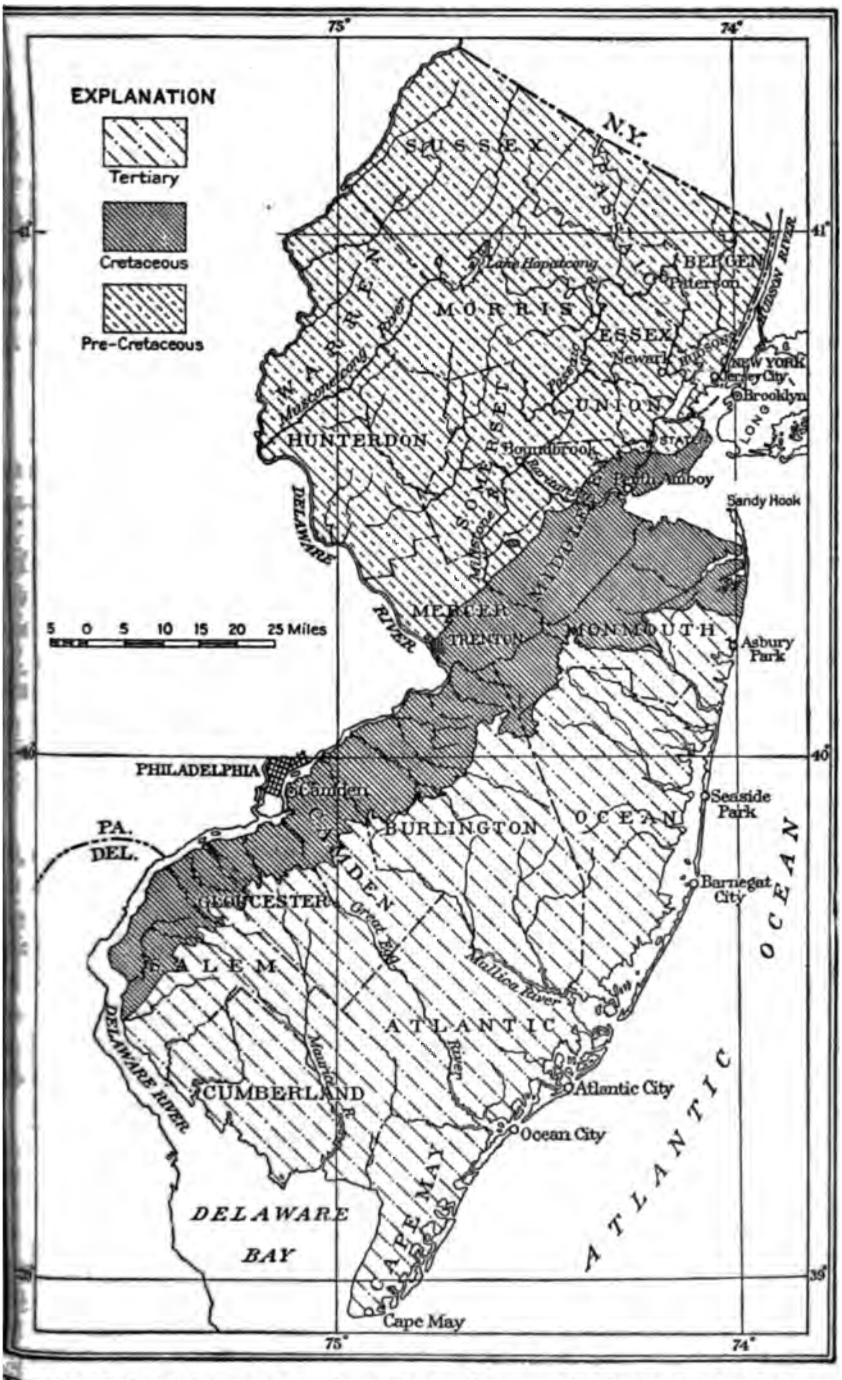


FIGURE 1.—Geologic index map of New Jersey, showing the general distribution of the pre-Cretaceous, Cretaceous, and post-Cretaceous formations.

Hopkins, of Hornerstown. Unfortunately time was not suffic
for drilling at all these places. Mr. William T. Hoffman, of
mingham, furnished useful information.

Messrs. Oren Conover and Chalkley Haines, of Woodstown,
William B. Cooper, A. G. Dunphey, and Samuel R. Cooper, of
ton, furnished local well data. Messrs. C. C. Holladay, of Harr
ville, John L. North, of Sewell, and S. J. Taylor, of Mount H
contributed well data and helpful field suggestions.

To the officials of the R. S. Ryan Co. the writer is indebte
numerous courtesies, especially to Mr. F. Tschirner, who condu
him through the plant at Reeves station while it was in oper
and permitted the collection of specimens and other data on the
pany's property. Mr. George F. Von Kolnitz kindly furnished
regarding the process and plans of the Atlantic Potash Corpora
Messrs. T. C. Meadows, general manager, and George Hafer,
neer of the Eastern Potash Corporation, furnished valuable info
tion and courteously arranged for an inspection of the corporat
experimental plant at Jones Point, N. Y. Mr. David L. F
vice president of the Coplay Cement Manufacturing Co., of Co
Pa., was kind enough to explain the company's experience i
use of greensand.

The personal kindnesses extended to the writer by the resi
at different places during the progress of the work are too num
to mention individually but are gratefully appreciated.

LOCATION OF DEPOSITS.

The greensand-marl belt extends across the State of New J posing to establish plants for utilizing greensand would do well to consider the possibilities of water transportation in their estimates of cost.

GENERAL FEATURES OF THE DEPOSITS.

CHARACTER

The potash occurs chiefly in the mineral glauconite, which constitutes the green grains of the so-called marl. The term "marl" as used in New Jersey includes a variety of materials. Thus we have greensand or glauconitic marl, clay marl, sand marl, and lime sand or lime-sand marl. Ordinarily greensand is implied when the term is used, but one or more of the other types is frequently included, especially in well records, so that it is difficult or impossible to make any detailed stratigraphic interpretation of many of these records.

The greensand beds are in general unconsolidated deposits consisting of variable proportions of glauconite grains, clay, quartz, and a variety of small fragments of other minerals. A more detailed description of these constituents and their relative proportions is given in the sections on mechanical analyses of greensand, chemical analyses, and nature and origin of glauconite. (See pp. 116–133, 138–142.)

The glauconite imparts a greenish color to beds in which it occurs, and beds consisting largely of dark-green or black glauconite appear nearly black when freshly opened. The claylike constituents, where abundant, impart color to the beds. Thus some are light green, but others are dark green, drab, or chocolate-brown, although in each bed the glauconite grains are generally dark-green or nearly black. Likewise where quartz grains are abundant the beds have a color resembling that of a mixture of pepper and salt. There is much similarity of appearance between masses of the black phase of the greensand and masses of disintegrated material from beds of black or brown oolitic phosphate rock in the Idaho field.

The glauconite grains range in size from less than one one-hundredth to more than one-twentieth of an inch. Some of the larger grains resemble casts of shells of Foraminifera. Many appear to be more or less irregular aggregates of small rounded masses, and others seem to be small nodules irregularly cracked and recemented. The smaller sizes are worn and have evidently been transported to their present positions from neighboring or other sources. (See Pl. IV.) Clay with grains of glauconite forms nodules and casts of shells. Nodules containing more or less pyrite are present here and there, and locally tiny grains of pyrite occur. Nodules of phosphate of lime are also present.

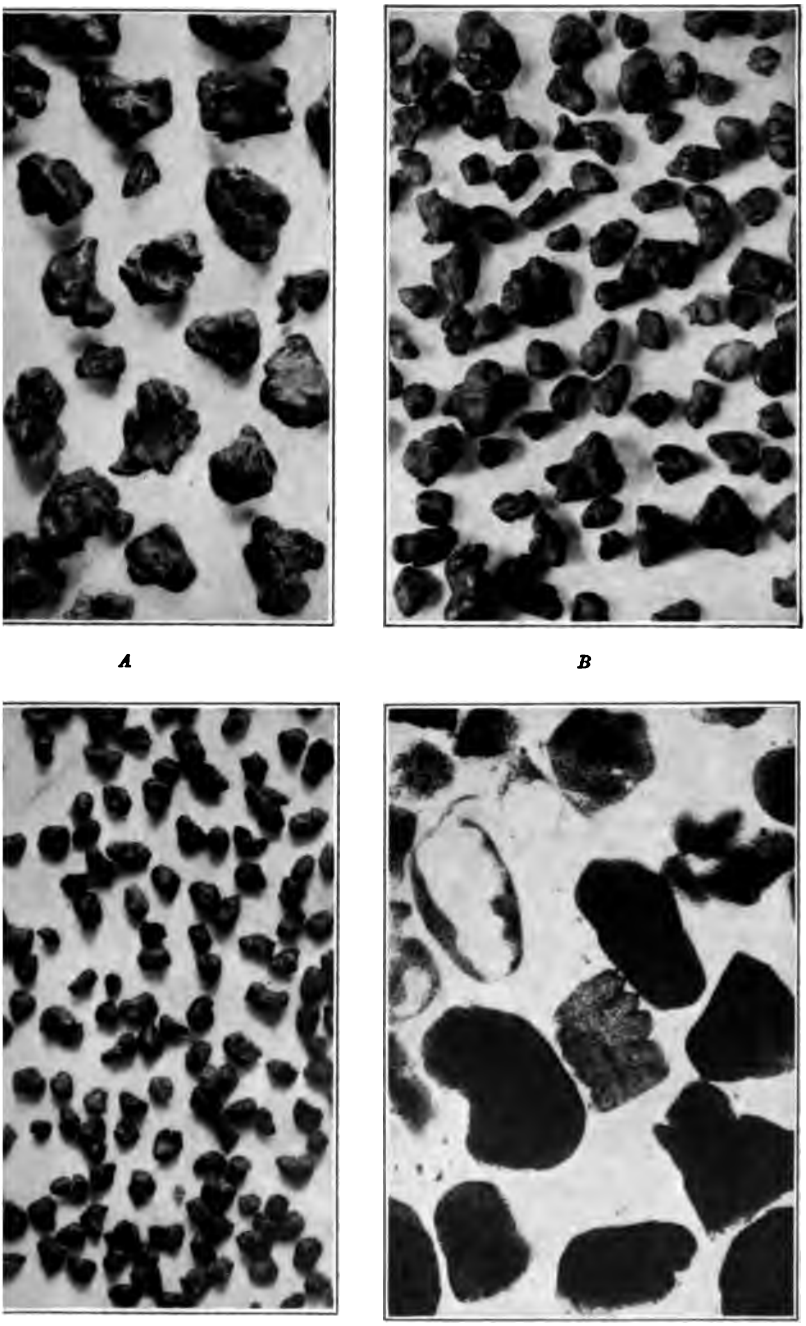
Marine shells and other marine fossils representing a considerable fauna have been found in the greensand beds. The shells are scattered to some extent through the mass of the greensand, but there are two beds in which they are very abundant and which serve as horizon markers. These are respectively the *Belemnitella*-bearing bed, at the base of the Navesink marl, and the *Terebratula*-bearing bed, at the top of the Hornerstown marl. These formations are described on pages 10 and 11.

The bedding of the greensand, so far as observed, seems relatively uniform and free from cross-bedding, though locally streaks of differently colored clay occur in a single set of beds. For example, at Sewell, where greensand is dug, the upper 2 feet of chocolate-colored material at the top of the so-called chocolate marl is streaked with green material of similar texture. At Somerdale a bed of drab material about 18 feet thick shows more or less streaking of gray and green throughout.

STRIKE, DIP, AND THICKNESS.

According to previous reports the average strike of the greensand beds is about N. 55° E. The dip is estimated by Knapp at 33 feet to the mile, with some variations, for a distance of 15 miles back from the outcrop; at greater distances it apparently steepens. The gentle inclination of the beds and the erosion they have suffered cause them to wedge out along the northwest margin of the marl belt. The thickness therefore ranges from a few inches along the northwest margin to nearly 50 feet in places along the southeast margin. Variations in thickness along the strike are due to local erosion or to differences in conditions of deposition.

LOCAL NAMES.



A *B*

C *D*

MICROPHOTOGRAPHS OF GLAUCONITE.

ains between 1/10 and 1/20 inch in diameter, the maximum size, × 10, showing characteristic
es; *B*, grains between 1/20 and 1/40 inch, × 10, shapes similar to those in A but more worn;
rains between 1/40 and 1/60 inch, × 10, shapes similar to those in *A* and *B* but considerably
e worn; *D*, thin section of glauconite grains between 1/40 and 1/60 inch, × 50, showing the
y to granular structure of the glauconite and in the center a supposed crystal with rude cleavage.

ↄoastal Plain in New Jersey has long been cited as an example belted type, with inner lowland, in-facing slope, out-facing ınd outer lowland, caused by the erosion of gently dipping ɔf somewhat unequal degrees of coherence or hardness and by velopment of drainage upon those strata. The marl beds r or at the top of the in-facing slope and thus relatively near ıre River, which occupies much of the inner lowland, and rainage in general flows toward that lowland, producing the ɔle conditions for water transportation previously noted.

CONITE-BEARING AND ASSOCIATED FORMATIONS.

ınd general sequence.—The glauconite beds of New Jersey, with ception, are of Cretaceous age. Glauconite occurs locally, ɜr, in some of the overlying Tertiary and Quaternary beds as a of the erosion and redeposition of Cretaceous material. At laces, as for example, at Somerdale, about 9 miles southeast of n, these reworked glauconite beds overlie beds of Cretaceous ınd and may readily be mistaken for them. Closer inspection reworked material reveals pebbles scattered through its mass ually a more or less well-defined layer of pebbles at its base. etaceous formations are described below and are shown with ɾrlying Tertiary formations in the accompanying table.[2]

Cretaceous and later formations in Coastal Plain region of New Jersey.

.	Series.	Formation.	Thickness (feet).
	Recent.	Beach sand and gravel, marsh deposits, and alluvium.	
y.	Pleistocene.	Cape May formation	0-20
		Pensauken formation	0-20
		Bridgeton formation	0-30
	Pliocene (?).	Beacon Hill gravel	
		-Unconformity?	
	Miocene (?).	Cohansey sand	100-250
		-Unconformity	
	Miocene.	Kirkwood formation	100
		-Unconformity	
	Eocene.	Shark River marl	11
		-Unconformity	
	Upper Cretaceous.	Manasquan marl	25
		Rancocas group:	
		Vincentown sand	25-70
		Hornerstown marl	30
		Monmouth group:	
		Redbank sand with Tinton sand member (10-20 feet) at top.	0-10
		Navesink marl	25-40
		Mount Laurel sand	5-60
		Matawan group:	
		Wenonah sand	20-35
		Marshalltown formation	30-35
		Englishtown sand	20-100
		Woodbury clay	50
		Merchantville clay	60
		Magothy formation	25-175
		-Unconformity	
		Raritan formation	150-250
		Great unconformity.	

ıd descriptions compiled chiefly from New Jersey Geol. Survey Bull. 14, 1915; U. S. Geol. Survey , Philadelphia folio (No. 162), 1909, and Trenton folio (No. 167), 1909.

Raritan formation.—The beds of the Raritan formation are of
tinental origin and extremely variable, consisting chiefly of li
colored sands and clays. Some of the clays are highly refract
Clays are more abundant in the lower half of the formation
sands in the upper half. Some of the sands are water-bear
As the surface on which the beds were laid down was irregular
thickness of the formation is variable, ranging from 150 to 250
at the outcrop but increasing toward the southeast to more than
feet, as shown by well borings. Its dip is somewhat steeper than t
of the marl beds, ranging from 40 to 50 feet to the mile toward
southeast. Animal remains are scarce, but plant remains are num
ous, and some of the genera and species are closely related to mod
forms. The formation rests in places on Triassic rocks, but from
vicinity of Trenton southward it rests on ancient crystalline ro
of Paleozoic or pre-Paleozoic age.

Magothy formation.—The Magothy formation is partly of co
nental and partly of marine origin and includes beds of sand and cl
some of which are utilized, with glauconite beds toward the top.
the shores of Raritan Bay the formation is 175 feet thick, but its thi
ness diminishes toward the southwest and along Delaware Rive
only 25 to 30 feet. Plant remains of a somewhat more recent as
than those of the Raritan are numerous, and 43 species of ma
fossils have been recognized. The Magothy lies unconformably u
the Raritan, but the discordance is not great and probably indic
only a slight land movement. The Raritan and Magothy formati
are the chief sources of clay in the great center of the industry ab
the lower Raritan River and Raritan Bay.

Merchantville clay.—The Merchantville formation is a black gl rved surfaces of fracture. Some 95 species of marine fossils have en recognized, and these are more closely related to the Magothy ecies than to those of the underlying Merchantville. The beds e conformable with those above and below. They represent the pper part of the "Crosswicks clay" of Clark and are part of Cook's Clay-Marl series." The formation is one of the five formations of e Matawan group.

Englishtown sand.—The Englishtown is a conspicuous bed of white r yellow quartz sand, slightly micaceous and sparingly glauconitic. ocally it has been cemented in part by iron oxide into massive one. South of Woodbury, in Gloucester County, it contains local eds of clay that are utilized for making brick. In Monmouth ounty and to some extent farther south the Englishtown sand is n important water-bearing bed. It decreases in thickness from 100 eet near Atlantic Highlands to less than 20 feet in the southern part f the State. It represents the lower part of the "Hazlet sands" f Clark and forms part of Cook's "Clay-Marl series." It was formerly called the "Columbus sand" and is one of the formations of he Matawan group. It is not known to contain fossils.

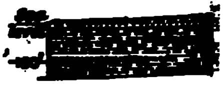
Marshalltown formation.—The Marshalltown formation ranges rom a black sandy clay to a clayey greensand marl. Locally it ontains many fossils, its characteristic species being in part recurrent orms from the Merchantville and in part forms that occur in a higher ormation, though absent or inconspicuous in immediately succeeding beds. The formation is 30 to 35 feet thick. It is a portion of the 'laminated sands" that formed the upper part of the "Clay-Marl eries" of Cook, although in the southwestern part of the State he eferred these beds to the Navesink marl. It was included in Clark's 'Hazlet sands" and is one of the formations of the Matawan group. n parts of Burlington and Camden counties beds of clay in the Marshalltown formation are used for the manufacture of brick. The greensand of the formation is locally abundant and has been dug for ertilizer.

Wenonah and Mount Laurel sands.—Above the Marshalltown ormation there is a considerable thickness of sand regarding which here has been some difference of opinion. The terms Wenonah and Mount Laurel have both been applied to it in whole or in part. The and is of rather uniform character, though the lower part (Wenonah) s generally a fine micaceous sand, and the upper part (Mount Laurel) s coarser and contains considerable glauconite. These sands conain considerable water in the southern and central parts of the State, here they are about 80 feet thick, but toward the northeast they ecrease both in thickness and in permeability.

The fossils of the Wenonah are largely recurrent from the
bury, and the same forms recur higher in the Redbank. The
of the Mount Laurel are identical with those of the Navesink a
closely allied to those of the Marshalltown. A noteworthy forn
occurs in the Mount Laurel and extends into the basal bed
Navesink is the pencil-shaped *Belemnitella americana*. The
bined thickness of the Wenonah and Mount Laurel formations
to 80 feet. The Mount Laurel is very thin at Atlantic High
where it was called "Sand-marl" by Cook, but increases mu
thickness toward the southwest. The Wenonah sand is the h
formation of the Matawan group; the Mount Laurel is the
formation of the overlying Monmouth group.

Navesink marl.—The Navesink marl consists of greensand
mixed with varying amounts of quartz sand and fine earth cont
much calcium carbonate in a powdery state. Where pure
marl has a dark-green to bluish-black color. The upper part
bed contains progressively less greensand and is more clayey.
fauna is large, comprising 121 species, according to Weller,
allied with that of the Marshalltown and Merchantville bed
characteristic forms of the Magothy, Woodbury, and Wenon
absent. The basal bed of the Navesink at many localities,
Mullica Hill, is a shell bed several feet thick (see Pl. VI, *B*), in
as in the Mount Laurel sand, the pencil-shaped *Belemnitella*
cana is conspicuous. Another characteristic feature of this
the occurrence of smoothed or polished gravel grains, chiefly q
about one-eighth of an inch in diameter, for which Knapp
gested the name "rice gravel." The formation has a maximum
ness of about 40 feet, which diminishes southward to 25 feet o

U. S. GEOLOGICA



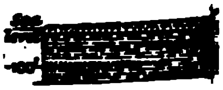
Vertical scal

glauconite together with sand and clay and has a green or g gray color. The upper 8 to 12 feet is made up of very fi mixed with greenish-white clay. Piles of this material look lil of ashes, whence the name "ash marl." Fossils are not abur well preserved. The thickness of the formation is about It corresponds to the "green" and "ash" marls of Cook's marl bed" and is the youngest of the Cretaceous formations in New Jersey. It rests conformably on the Vincentown most exposures is succeeded unconformably by Tertiary ternary deposits, although locally it is overlain by a bluish Eocene age (Shark River marl) without apparent uncon The Manasquan marl has been dug and extensively used as f

Tertiary and Quaternary formations.—Aside from the local of reworked material already mentioned the Shark Riv (Eocene) is the only post-Cretaceous formation that car nificant amounts of glauconite. The Shark River marl crops in a few small areas near Long Branch and Farmingdale, mouth County. Its maximum thickness is only 11 feet, and apparently conformable upon the Manasquan it is believed fr borings to overlap the Cretaceous. It has little commer portance.

The succeeding formations are sufficiently described for t poses of this report in the table on page 7. They constitut of the overburden to be encountered in exploitation of the m

Commercially important formations.—Although most of th



Vertical scal

sink marls to merge in a single formation in which both faunas be recognized, but the respective parts of the formation are learly differentiated. Similarly the Manasquan marl practically pears at a point about 4 miles southwest of Medford, in Burling- County. It has been recognized about 8 miles farther south- in a small exposure near Clementon, in Camden County, and in des Run, Salem County. Thus southwest of the vicinity of lton, in Burlington County, the marl belt practically includes the combined bed of Navesink and Hornerstown and the Vin- own sand, which in that portion of the belt is locally very cal- ous.

GEOLOGIC STRUCTURE.

he geologic structure of the New Jersey Coastal Plain, as shown late V, is that of a series of gently inclined layers of poorly con- dated rock which have been beveled by erosion and many of ch have been covered to a greater or less extent by later deposits. se layers of rock may be regarded as in large measure continuous oughout much of the Coastal Plain. Northwest of the area of its crop any particular bed is absent, but southeast of that area its th increases regularly in the direction of the dip.

n idea more or less current in the marl region is that the marl g streams is of better quality than that in places between streams. sideration of the structure as above outlined should show that a am bears much the same relation to a marl bed as a carpenter's ge or saw would to a board that was being shaped or cut. The l might disclose differences in the grain or quality of the wood he board but would have no part in producing those differences. he analogy between the marl and the board is not complete, vever, because ground water percolates through the marl at ny localities and might be thought capable of removing fine par- es, especially beneath stream beds, where underflow may be sumed to be relatively strong. Without a definite knowledge of amount and distribution of the pore space of the marl in place s impossible to deny that some removal of fine particles and con- uent enrichment of remaining coarser material may be effected ground water. On the other hand, the marl generally is com- t, and the motion of ground water through it must be slow. The re clayey portions of the marl are in many places so tenacious t small dislodged masses of it successfully resist agitation in ter for periods of several minutes. The differences noted in the rl are more probably to be ascribed, like the grain of the wood the board, to original structure. If better marl has been found g streams than elsewhere the reason is probably because it is re abundantly exposed in stream valleys than elsewhere and

hence has been more commonly dug along the valleys. I
reference to enrichment is made on pages 133–135.

The gentle dip of the marl beds, previously noted, makes tl
of their outcrop relatively broad and its outline intricate
crossed by streams. (See Pls. I–III, in pocket.)

NATURE OF THE EXPOSURES.

In fields and in roads the greensand gives a greenish color
soil. In such places, however, the marl is likely to be n
with other material. Locally it has proved to be redeposited
sand, and gravel of Quaternary age.

In the days when Cook wrote his general report on the geol
New Jersey, published in 1868, the marl business was flour
marl pits were open and shipping was in progress at many
all along the marl belt. With the introduction of prepared
zers and the decline of the marl industry most of the pits were
doned and given over to water, swamps, and vegetation
sides or banks have slumped and are now overgrown with bru
trees, some of which have trunks 3 to 6 inches in diameter, as
large pit 2 miles northeast of Richwood, in Gloucester County (1
44, Pl. I).

At a few pits, notably at Sewell and Birmingham, diggin
progress or has been recently. These pits give excellent exp
of portions of the beds but do not afford complete sections.
VI, *A*, shows some of the recent diggings and gives an idea
present condition of one of the larger of the old pits. (See a
IX, p. 80.) Exposures in road cuts give only partial sectio

A. GENERAL VIEW OF WILLIAM HOFFMAN'S MARL PIT AT BIRMINGHAM, BURLINGTON COUNTY, N. J.

About three-fourths of a mile northwest of station. Shows recent digging at the north end and, in the distance, the old west bank of the pit.

B. SHELL BED AT THE BASE OF THE NAVESINK MARL AT MULLICA HILL, GLOUCESTER COUNTY, N. J., JUST EAST OF STATION.

nonstrated the need for drilling. Bids were invited, and the ıtract was let to Samuel J. Taylor, of Mount Holly.

In the selection of sites for drilling five requisites were considered.) The sites must be so spaced as to represent a considerable portion the marl belt; (2) each site must be located in a tract large enough ıd flat enough for the establishment of a plant and the opening of ts; (3) the probable overburden should not exceed 10 to 15 feet;) the site must be along the southeast edge of the outcrop belt in der that the maximum thickness of the marl might be available;) the site must be near suitable means of transportation. On the asis of these requisities preliminary sites and alternates were se-cted by study of the map. These sites were then visited and the urrounding country inspected before final decision was made. The wnership of the land was then determined, and permission for rilling was obtained.

In such manner sites were selected at Salem and Woodstown, in alem County; Sewell, in Gloucester County; Somerdale, in Camden ounty; Elmwood Road, in Burlington County; and other places hich it was found impracticable to utilize. At each site a square ontaining 2½ acres was selected. Holes were sunk at each end of ne side and a third hole for a check at the end or middle of the pposite side. At Salem and at Somerdale a fourth hole was sunk utside the square, but at Elmwood Road only two holes were sunk, he contract having expired before the third hole could be started. During the period November 20, 1918, to March 13, 1919, 16 holes were drilled under the contract. These were all in the combined Hornerstown and Navesink marls. In addition, through the courtesy f Mr. A. J. Mullen, superintendent of the Norcross & Edmunds Co.'s plant at Birmingham and Pemberton, men and tools were furnished for sinking three holes in the Manasquan marl on the property of that company. The distances between drilling sites range from 8 to 12½ miles.

The holes were sunk generally into or through the marl. They anged in depth from 9 to 70 feet and averaged 37 feet. Of the 16 oles bored under contract 12 afforded complete sections from the urface through the marl beds. Observations were made on the haracter and thickness of the materials penetrated, and about 140 amples were collected for analysis. Numerous well records were lso gathered.

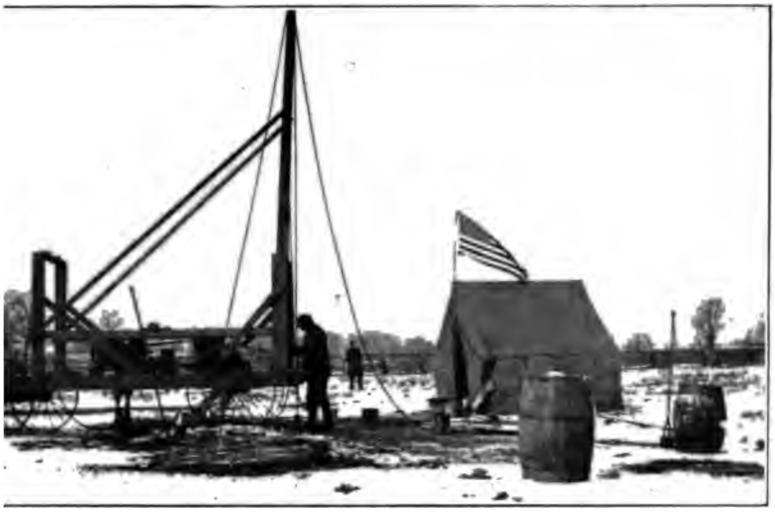
After the drilling was completed a trip with the State geologist nto parts of Monmouth County gave opportunity for brief inspection f additional portions of the marl belt.

Method of drilling.—Considerable variation was found in the char-cter and behavior of the overburden and of the marl in regard to rilling at the different sites and in the different holes at the same site. Equipment and methods that worked well at one hole would be unsatisfactory at another. Thus at almost every hole a certain amount of experimentation was necessary to facilitate the work.

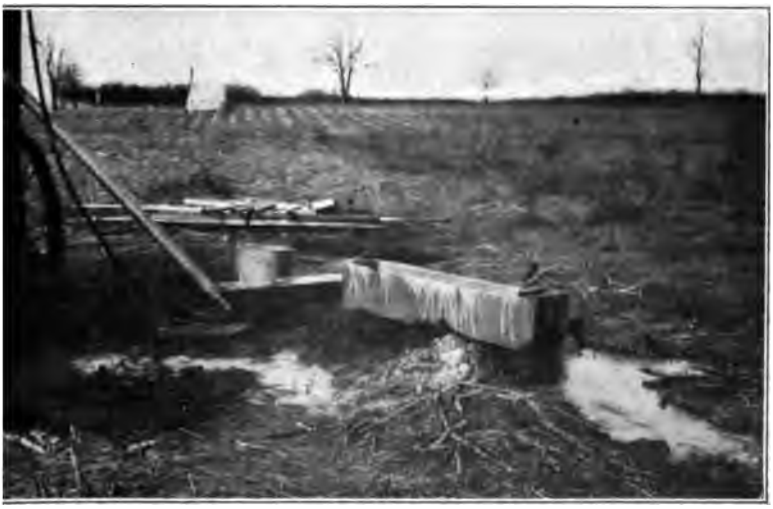
For two of the holes at Salem and for the first hole at Woodstown a light outfit, consisting of a 10-horsepower engine, winch, and tripod composed of 20-foot lengths of 1¼-inch pipe, was employed. Three-inch casing was used, and the drill bit and sand bucket were operated with ropes. Water filled the holes within a few feet of the surface. The marl had comparatively little binder, so that it could be removed only as sludge in the sand bucket. It was therefore necessary to follow the drill closely with the casing. For two of the holes at Salem a Cyclone drill of standard pattern was used. At Woodstown the tripod of the light outfit was replaced by a wooden derrick built into a portable rig, on which the engine and winch were also mounted (see Pl. VII, *A*), and this rig with modifications was used throughout the rest of the contract work.

In some of the holes where conditions were favorable the marl was removed directly with an auger. In some of the holes also a cylindrical tube was attached to the drill bar and driven down to obtain a core. This method proved on the whole unsatisfactory. There was more or less interchange from rope to rod tools and back again. The most rapid progress was made by the use of the drill bit and sand bucket attached to light rods and operated by hand by two men. On the Norcross & Edmunds property an 8-inch posthole auger with overlapping blades, one of which could be raised for removing the load, was used. This was operated by two men.

Method of sampling.—In sampling, as in drilling, the varying conditions at succeeding holes required more or less experimentation at



ILLING OUTFIT AND OPERATIONS AT WOODSTOWN, SALEM COUNTY, N. J



MPLING TROUGH IN USE AT ELMWOOD ROAD, BURLINGTON COUNTY, N. J.

much water was present in most of the holes that the auger was rally ineffective at depths greater than 10 to 25 feet. The drical bit with vertical slit for cleaning was effective in a few es, but where the material was incoherent it could not be brought e surface. The more tenacious beds were penetrated only with culty by the cylinder, and the removal of material from it was slow. The most expeditious method was drilling and sludging the sand bucket, care being taken to case off beds that would be ly to modify the sample. Several samples taken by the auger or nder were taken in duplicate by the sludge method as a check.

ome experimentation was necessary in handling the material ected for samples. At hole 1, at Salem, the sludge was strained cheesecloth spread over a perforated bucket or on screens on the und. There was some loss of the claylike fines, but the lower rs of the sludge served as a filter for overlying layers, so that the of fines was thereby reduced. The remaining moist material, h a texture of somewhat clayey sand, was kneaded on oilcloth or vas and divided six to eight times to duplicate samples weighing ut 1½ pounds.

t hole 3, at Salem, the sludge was collected in barrels and allowed ettle over night, the water being then siphoned off. The remain- material was too wet to divide on canvas. It was therefore roughly mixed in the barrels and divided by discarding alternate ketfuls until duplicates weighing about 1½ pounds were obtained. s method also involved some loss of fines because of the slow ling of the claylike portion and the difficulty of siphoning without ring the light fines.

t Woodstown two especially constructed boxes, each fitted with a of three screens, were employed. The solid material from the lecting barrel was spread on cheesecloth on the screens in the hope t it would filter the clayey water of the sample, which was then red into the boxes. The operation was not successful. Either water would pass through, or if it did the colloidal matter passed ough with it. The collecting and filtering operations, both at em and at Woodstown, were seriously hampered by freezing. tering was abandoned, and the plan of dividing the solid and uid portions separately and proportionally was tried, the end prod- s of each division being combined for the final sample, which s then dried in pans over oil stoves, care being taken to avoid rheating and oxidation of the glauconite. It was feasible to lect some of the samples at Woodstown by means of the auger and core tool. These samples were mixed and divided on canvas and ed on oil stoves.

t Sewell it was also possible to collect some of the samples with- t sludging, but that method proved necessary for many of them.

The labor of mixing and dividing large quantities of marl was obviate by using a trough with an end gate for collecting the sludge, as show in Plate VII, *B*. The sludge in the trough was mixed thoroughly and a sufficient quantity ladled out to provide duplicate samples one of which was dried as above described and the other preserved in a 4-ounce wide-mouthed bottle. If more than one troughful was required for a given sample, proportionate amounts were preserved from each troughful and were mixed and divided for the final sample. This method was used at the other localities whenever sludging was necessary, care being taken to keep the sludge as thick as possible and to operate the sand bucket so as to take only material from the bottom of the hole.

Disadvantages of wet method.—The main disadvantage of the wet method of collecting marl samples is that by loosening the marl some of the finer constituents are mingled with water, and the relative proportions of coarse and fine materials are thereby slightly altered. The coarse constituents of the marl are relatively heavy and settle rapidly to the bottom of the trough, so that it is frequently difficult to get a uniform mixture. There is danger, too, of intermixture of material from farther up the hole, but this may be obviated to a considerable degree by suitable casing.

As shown on pages 125–126, the finer constituents of the marl contain potash in amounts varying from place to place and in different beds at the same place. Where the potash content of the fines of a given sample is less than that of the sample as a whole a loss of fines in collection would mean some enrichment of the sample, or an undue amount of fines collected would mean a corresponding impover-

Determination of weight.—The density and moisture content as well as the potash content were determined for several samples of greensand, as shown in the accompanying table.

Potash, moisture, and density determinations for selected samples of New Jersey greensand.

[R. K. Bailey, analyst.]

Field No.	Locality.	K_2O.	H_2O at about 100° C.	Density.
		Per cent.	*Per cent.*	
M-7	Hole 3, Salem, (p. 23)	6.14	[a] 18.48	....
M-9	Hole 5, Woodstown (p. 31)	6.48	23.97	....
M-10	Hole 5, Woodstown (p. 31)	7.56	24.45	....
M-63	Sewell, West Jersey Marl & Transportation Co	7.80	20.50	2.958
K	Atlantic Potash Co., about 1½ miles east of Marlton	7.63	14.20	2,925
R	R. S. Ryan plant at Reeves station, 2 miles north of Medford	6.25	17.38	3.063

[a] Sample damaged before reaching laboratory and contents transferred to bottle; hence H_2O content may be lower than that of actual sample.

Samples M-7, M-9, and M-10 were collected with the idea of finding how much water the greensand would retain when saturated. They were collected in an excess of water and forwarded to the laboratory in sealed cans. Before analysis they were placed in containers which would prevent evaporation but permit the excess water to drain away. The analyses show that marl taken directly from the pit and loaded without drying in wagons or freight cars, as was done by one company, may contain from 18.5 to nearly 25 per cent of water.

Sample M-63 was collected from a fresh stock pile gathered for shipment at a pit about three-quarters of a mile S. 70° E. from Sewell station and had been taken from the pit only a few moments before collection. It is a mixture of gray and dark-green marl.

Sample K was taken from a depth of 20 to 32 inches in the top of a stock pile that was probably less than a year old. It consisted of a mixture of green and brown marl judged in the field to be of excellent quality.

Sample R came from a freshly opened bed about 10 feet below the surface. It was black marl of apparently good quality.

Four determinations of the weight per cubic foot of greensand as taken from the ground were made in the field by weighing the material used to fill evenly a measured box of convenient size. A sample of the same material in each lot was preserved for the determination of moisture. The average weight of the material as taken from the ground according to these measurements was about 93 pounds to the cubic foot, or about 2,500 pounds to the cubic yard. The average weight of the dried material calculated from the moisture percentages in the above table was about 79.5 pounds to the cubic foot. A fifth determination of dried residues from several samples obtained at hole 6, Woodstown, gave 81.8 pounds to the cubic foot, but some of these residues had been exposed to the air for several days after drying. The average weight of the five dried samples was about 80 pounds to the cubic foot, or 2,160 pounds to the cubic yard.

The figures given above are probably fairly accurate for the weight of the better material as ordinarily handled. Estimates of tonnage, however, are concerned with marl in the ground, which is presumably much more compact than marl removed to stock piles. According to the density determinations given in the table the weight of dry greensand, if massive and compact, would range from 182.7 to 191.4 pounds to the cubic foot and would average about 186 pounds to the cubic foot, or more than 5,000 pounds to the cubic yard. The marl in the ground, being unconsolidated, is probably much less compact than the degree required by this figure. Its actual weight doubtless lies between the two extremes given and for the purposes of estimate may be assumed to be their mean, 133 pounds to the cubic foot or about 3,580 pounds to the cubic yard. The voids, or open spaces due to lack of consolidation, would represent on this assumption 28 per cent of the mass of the marl.

Collection of well data.—During the progress of field work several well drillers were interviewed and farms on which wells had been sunk were visited. The well records at the office of the State geologist at Trenton were searched for data bearing on the districts explored. Published accounts were also reviewed with the hope of extending the inferences based on the drilling.

Other field data.—The field notes of the State geologist and his staff were kindly placed at the disposal of the writer and have been utilized to supplement the information gained by drilling.

GEOLOGIC MAP.

ılities discussed are referred so far as practicable to the ;. I–III), consecutive numbers being employed in order of The locations of many of the wells are not accurately the available descriptions. The positions of such wells .ted on the maps with a query (?).

RESULTS OF FIELD WORK.

SALEM DISTRICT.

SELECTION AND LOCATION OF SITES.

.ed accounts give little information about greensand marl m, but the geologic map of the State shows both the com- rnerstown and Navesink marls and the Vincentown sand ; broad areas near Salem and passing southwestward to River. Salem has railroad facilities and, through Salem d its tributary Fen- ›k, excellent means of ınsportation. It was decided to make Salem ng point in the inves-

ected drilling sites lay ıite sides of Walnut ›out three-quarters of 23° W. from the court- ı the farms of Louis T. R. Miller. A sup- ry hole was started in belonging to Lucius ɔut a quarter of a mile :he other sites.

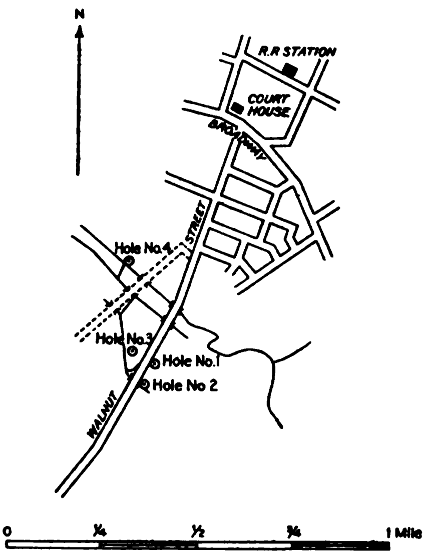


FIGURE 2.—Sketch map of part of the Salem district, showing the location of holes 1–4.

HOLES 1 TO 4.

7erburden at hole 1 ɔ thick, 25 feet, that cial development nlikely. It was therefore determined merely to check the and character of the overburden at the other holes in that ınd to confirm the character of the marl at one other local- ıs at hole 2 only the overburden was penetrated; at hole 3, ›urden and 16 feet of marl, enough to show the presence of :ommercial quantity and quality. At hole 4 the drill stuck at a depth of about 9 feet. Work was discontinued because ckness of the overburden in holes 1 to 3 and the reported of overburden in wells in the vicinity. The positions of ıoles are shown in figure 2; their records follow.

Southeast of the area mapped as Vincentown three addition borings throw light on the thickness and character of the overburde in that district.

A well drilled for Dr. Hummel at Sandy Ridge farm (locality 9 about 1 mile N. 42° W. of the Quinton railroad station, show according to C. C. Holladay, driller, 36 feet of overburden and 2 feet of "light-colored marl." This marl may be Vincentown, but i lies within the area mapped by the State Geological Survey as Kirkwood and may represent a marly phase of that formation, whic farther southeast is known as the Shiloh marl member of the Kirkwood formation, and was formerly dug as a fertilizer.[6]

A well near Hagerville gives the following record:

Record of well of James Pettit at locality 10, about half a mile southeast of Hagerville

[South side of road. Elevation, 5± feet. C. C. Holladay, driller and informant.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Clay, gravel, and sand	17	17	Pleistocene.
Shell marl; effervesces strongly with acid	10	27	Kirkwood (?).
Quicksand	58	85	Do.
Sand and coral; stopped in coral	15	100	Vincentown (?).

It is supposed that the upper bed of marl in this well may represent the Shiloh marl member and the lower bed the lime sand or Vincentown. Upon this assumption the Hornerstown marl at locality 10 will lie 110 feet or more beneath the surface.

The well of Jerry Powell, on the west bank of Hope Creek near it mouth (locality 11), "a stone's throw from the Delaware," is sai

Combined record of two wells 2½ miles east of Alloway.

[No. 1: Elevation, 40 feet; depth, 240 feet; driller, Abraham Darlington. No. 2: Elevation, 30 feet; depth, 205 feet; drillers, Haines Bros.]

	Thickness.	Depth.	Age or formation.
	Feet.	*Feet.*	
Yellow clay	18	18	Miocene in part at least.
"Blue mud"	90	108	
"Marl and sand"	72	180	Mostly lime sands [Vincentown].
Gray rock	7½	181½	Do.
Sand, water-bearing	8½	190	Do.
Gray rock (9 inches)	1	191	Do.
"Marl and sand," well No. 2	14	205	Middle marl.
Do	35	240	[Hornerstown and Navesink].

The thickness of the lime sand here is noteworthy, as is also the thickness of the marl, which lies 191 feet below the surface.

Record of well of Salem Water Co. at Quinton.[a]

[Depth, 248 feet; Kisner & Bennett, drillers.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Surface soil	1	1	Recent.
Gravel	3	4	Do.
Clay with shells	26	30	[Kirkwood.]
Green and white sandy, clayey marl	8	38	[Manasquan.]
Alternations of lime sand and limerock.	108	146	[Vincentown.]
Clay	2	148	[Hornerstown and Navesink.]
Greensand marl and shell comminuted by drill	14	162	Do.
Clay	4	166	[Mount Laurel and Wenonah.]
Gray quartzose sand with water	82	248	Do.

[a] New Jersey Geol. Survey Ann. Rept. for 1894, p. 194, 1895.

In the above record the formation names in brackets are substituted by the writer for those used in the report cited. The thickness of the lime sand (108 feet) is remarkable. The thickness of the combined Hornerstown and Navesink is rather low.

OTHER DATA.

The exposures of the three important marl beds nearest to Salem occur along Mannington Creek and its tributary Swedes Run in Mannington Township, from 3 to 5 miles northeast to nearly east of Salem. The limestone phase of the Vincentown sand is also exposed at the same locality. These formations were dug and utilized as fertilizer years ago, and analyses of samples from them are given by Cook.[b]

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[b] Cook, G. H., Geology of New Jersey, pp. 441-442, 1868.

LIME SAND.

The use of lime in extracting potash from greensand lends in to the occurrences of the lime-sand and limestone phases of th centown sand as possible sources of the lime. The following an given by Cook show the character of this material:

Analyses of limestone and lime sand from the Vincentown sand in Mannington Tou

	1	2	3		1	2
Phosphoric acid	0.04	0.20		Alumina	0.91	0.86
Sulphuric acid	.06	.23		Oxide of iron	3.07	3.56
Silicic acid	23.31	8.11	43.40	Carbonate of lime	69.61	84.73
Magnesia	1.81	1.40	1.95	Water	.24	.45
					99.05	99.54

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[a] Cook, G. H., op. cit., pp. 441-442.

No. 1 is described as a fair sample of the "Yellow limeston Mannington Township. No. 2 is described as lime sand from John Fowler, Swedes Bridge, Mannington Township. This sample of the loose variety, is gray in color, and contains many sand grains. No. 3 is described as lime sand from William Ba pits, along a branch of Mannington Creek, Mannington Tow This lime sand was extensively used as a fertilizer. The stony were burned for lime, which had a wide use and gave good sa tion.

These pits have long been idle and have probably passed into ownership, but the general locality can readily be identified fro map. The average content of carbonate of lime for the three sa is 66.3 per cent. The low magnesia content is noteworthy.

ESTIMATES OF TONNAGE AND VALUE.

At locality 1 the thickness of the marl sampled was 23.3 feet. At locality 3 the thickness sampled was 15.5 feet, but the marl at this locality was not penetrated. The average of the thicknesses sampled is 19.4 feet, but for purposes of computation it may safely be assumed as 20 feet. The average potash content, weighted according to the thicknesses represented by the respective samples, is 6.62 per cent. The weight per cubic foot of marl, on the assumption of 28 per cent of voids, as explained in a previous paragraph, is 133 pounds. On this basis 1 acre would contain $\frac{43,560 \times 20 \times 133 \times 0.0662}{2,000} = 3,800$ tons of potash (approximately), and 2.5 acres would contain 9,500 tons.

With an 80 per cent recovery and a price of $2.50 per unit (March, 1920), the available potash in a ton of greensand from the localities sampled (6.62 per cent K_2O) would be worth $13.24 and that in an acre $760,000. It is doubtful, however, if the price of potash can be maintained at that figure. At $1.50 per unit under the same conditions the available potash in a ton of greensand would be worth $7.94, and that in an acre $456,000. These values have only theoretical interest, as they depend upon the potash being made available by processes whose success has not been demonstrated.

Although the estimates given are for a single area of 2.5 acres the well records cited show that greensand marl occurs generally beneath the Salem area. The wells at localities 5, 6, and 8 show thicknesses of greensand ranging from 25 to 40 feet. These wells, as also the borings at localities 1 and 3, are near the southeastern border of the beveled greensand belt, where the thickness is greater. Toward the northwest the thickness may be presumed to diminish to zero along the general northwestern border of the belt.

UTILIZATION OF THE DEPOSITS.

The record of the well at locality 7 appears to show that the overburden may not be as thick along Fenwick Creek as elsewhere in the Salem district. On the other hand, the marl shown in that record may be reworked material of Pleistocene age and if so may have a lower percentage of potash than the undisturbed Cretaceous deposits. Systematic prospecting along the creek would be necessary to settle these uncertainties.

Elsewhere the overburden in the Salem district appears to be too thick to permit any immediate utilization of the greensand in the Hornerstown and Navesink marls, but the deposit may be regarded as a resource of possible future value.

Records of holes in Salem district.

Locality 1, hole 1.

[Farm of Louis Fogg, Walnut Street, Salem, about three-quarters of a mile S. 23° W. of courthouse. vation of surface, about 2 feet. S. J. Taylor, driller. Analysts: Chase Palmer (M-1 to M-4), R. K. Ba (M-5.)]

	Thickness.	Depth.	Field No. of sample.	K_2O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
Top sod and dark soil	1	1	....	....	Recent.
Clay, dark gray, sandy, with scattered quartz pebbles and including 6-inch water-bearing bed of yellow pebbly sand at depth of 3 feet 3 inches.	5 8	6 8	....	....	Pleistocene.
Gravel, coarse and fine angular fragments $\frac{1}{16}$ inch to 2 inches in diameter, chiefly quartz, with some chert. More or less alternation of sand and gravel with considerable yellow clay, pebbles becoming more rounded. A few weathered needles of amphibole (?).	4 4	11	....	....	Do.
Sand, deep yellow to orange-yellow, with black specks; contains scattered tiny pebbles, especially near the top. Lowest foot glauconitic.	14	25	....	....	Do.
Clay, glauconitic, yellowish green, somewhat sandy, containing scattered pebbles $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and scattered chocolate-colored clay pellets.	1	26	M-1	6.11	Hornerstown[a]
Glauconite beds, clayey, yellowish, with some coarse particles of quartz; grades into clay above. At base a few ferruginous and clayey nodules $\frac{1}{4}$ to $\frac{3}{4}$ inch in diameter and containing grains of glauconite.	4	30			
Glauconite beds with more or less grayish-yellow clay intermingled. Lowest foot nearly black; some nodules with grains of glauconite.	7 4	37 4	M-2	6.30	Do.
Glauconite beds, black, with grains of glauconite as large as $\frac{1}{16}$ inch in diameter and a few grains of quartz.	4 3	41 7	M-3	6.57	Do.
Glauconite beds containing considerable greenish clay, scattered tiny pebbles of quartz about $\frac{1}{8}$ inch in diameter, and glauconitic concretions as large as $\frac{1}{2}$ inch in diameter.	1	42 7			
Glauconite bed like last but toward base containing shell bed that was not measured but is probably only a few inches thick.	3 9	46 4	M-4	7.27	Do.
Glauconite beds with greenish clay in somewhat larger proportions than above. Some fragments of large shells (*Exogyra* or *Gryphaea*) and broken casts composed of consolidated	2	48 4	M-5	7.26	Navesink (?)[a]

Locality 3, hole 3.

ng to T. R. Miller, on Walnut Street, about three-quarters of a mile south of courthouse 30 feet N. 38° W. from hole 1. Surface elevation, about 2 feet. C. C. Holladay, driller. Bailey.]

	Thickness.	Depth.	Field No. of sample.	K$_2$O.	Formation.
	Ft. in.	Ft. in.		Per cent.	
k muck	2	2	....	....	Recent (?).
y, very smooth and soft, not below soil in holes 1 and 2.	7	9	....	....	Do.
ty, with pieces of twigs and	7	16	....	....	Do.
containing small quartz pebble of greenstone 2 inches in mes yellowish and finer texins of glauconite in the lower	5	21	....	....	Pleistocene.
, containing some yellowish	5	26	M-7	6.14	Hornerstown.
t first coarse, then finer, with ay.	5	31			
with considerable green clay grains of quartz as large as r; lumps of green clay containgrains indicate more clayey	5 6	36 6	M-8	7.72	Do.
ke those above; not penetrated.	6	37	....	....	Do.

Locality 4, hole 4.

ng to Lucius Hires, about 1,350 feet N. 10° W. from hole 1. Elevation of surface, about 2 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Formation.
	Ft. in.	Ft. in.	
soil and muck	1 6	1 6	Recent.
y	4 6	6	Pleistocene.
clayey, containing a few angular quartz ray sandstone pebble 2 inches in diameter.	6	6 6	Do.
se pebbles, chiefly quartz, some as large as meter; not penetrated further.	2 1	8 7	Do.

of holes 1 to 3 are summarized in the following table:

Thickness and quality of greensand beds at holes 1 to 3, Salem.

Bed.	Sample.			Thickness of bed.	Average content of K$_2$O.[a]
	No.	Thickness represented.	K$_2$O.		
		Ft. in.	Per cent.	Ft. in.	Per cent.
len	....	....	....	25	....
d	M-1 M-2	5 7 4	6.11 6.30	12 4	6.22
ed	M-3 M-4	5 3 3 9	6.57 7.27	9	6.86
d	M-5	2	7.26	2	7.26
len	....	....	....	25 5	....
	....	....	....	21	....
d	M 7	10	6.14	10	6.14
ed (not penetrated)	M-8	5 6	7.72	5 6	7.72
burden	....	....	....	23 10	....
r bed	....	....	....	11 2	[b]6.19
le bed	....	....	....	[c]9±	[b]7.19
r bed	....	....	....	2±	[c]7.26
				22 2	[d]6.69

ed weighted according to thickness represented by the respective samples.
ed in 2.5-acre tract weighted according to thickness at respective holes.
ole 1 only.
ntire thickness of marl in 2.5-acre tract, assuming that thicknesses for middle and lower ply to entire area.

Locality 13, hole 6.

[Field of Isaac K. Lippincott, Woodstown, 375 feet N. 30° E. from hole 5. Elevation of surface abo
feet. S. J. Taylor, driller; R. K. Bailey, analyst.]

	Thickness.	Depth.	Field No. of sample.	K₂O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
Top soil, dark, clayey, with some sand..........	1	1	....	....	Recent.
Clay, sandy, grayish..............................	4	1 4	....	....	Pleistocene.
Gravel, yellow, in matrix of sand and clay; quartz pebbles as large as 2½ inches in diameter.	8 8	10	....	....	Do.
Glauconite beds, stiff, with dark-greenish to black clay, containing some small rounded quartz pebbles ⅛ inch in diameter. One smooth ovate pebble noted at bottom.	3 1	13 1	M-12	5.74	Hornerstown.
Glauconite beds, clayey, homogeneous, with somewhat larger proportion of black glauconite.	5 3	18 4			
Glauconite beds similar to above but including at base a few inches of underlying stratum.	2 2	20 6	M-13	5.79	Do.
Glauconite beds with greenish-drab clay, much intermingled quartz sand, and yellow grains probably of weathered ferruginous chert; coarser grains of clear and yellow-stained quartz and chert as large as ⅛ inch in diameter, angular and rounded; runs into pipe, water bearing; not sampled.	1 4	21 10	....	....	Do.
Glauconite beds, black, clayey, viscous, apparently uniform. (Sample M-14=2 feet of material from 21 feet 10 inches to 23 feet 10 inches.)	3 2	25	M-14	6.98	Do.
Glauconite beds, green, larger proportion of glauconite; runs easily; uniform character; sample bailing taken at depth of 29 feet. One fish tooth observed.	5	30	M-15	7.88	Do.
Glauconite beds, green, greater proportion clay, stiff, fine textured, apparently uniform. Sample M-16 represents material from depth of 30 to 31 feet.	4 7	34 7	M-16	7.80	Do.
Glauconite beds, less clayey, green material with larger proportion of glauconite, fine texture, soft; tends to run. Sample M-17 taken from a bailing at depth of 34 feet 7 inches but apparently representative of entire thickness.	5 5	40	M-17	7.76	Do.
Glauconite beds, brownish black, comparatively little clay. Sample M-18 taken from a bailing at depth of 40 feet but considered representative of entire thickness.	3 6	43 6	M-18	7.56	Navesink.
Glauconite beds, brownish black, containing gravel, sand, clay, and much glauconite. Gravel grains $\frac{1}{16}$ to ¼ inch in diameter; some of	1 6	45	M-19	2.92	Do.

The northwestward beveling of the greensand marl by erosion is perhaps shown by the following record:

Record of well of H. J. Heinz Co. at locality 7, Salem.

[Fenwick Creek, about 0.35 mile N. 42° W. of railroad station. Elevation, about 3 feet. C. C. Holladay, driller and informant.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Clay	8	8	Pleistocene.
Green marl	3	11	Hornerstown and Navesink (?).
Black sand or blue marl	6	17	Do.
Yellow sand	53	70	Do.
Gravel and gray sand	5	75	

If the green and blue marl of the above record are undisturbed a diminution of 26 to 31 feet in the thickness of the marl has occurred between localities 6 and 7. The overburden also has been reduced from 20 or 30 feet to only 8 feet. The thick yellow sand and the gravel in the lower part of the hole suggest that the entire mass of the material penetrated by the well may be Pleistocene and may represent filling in the formerly more deeply eroded valley of Fenwick Creek. Present data are insufficient to determine this point.

A 40-foot well drilled by Haines Bros. for Howard Harris[5] about 1 mile west of Salem penetrated only fine yellow sands to a point near the bottom, where the color changed to white. These sands are probably Pleistocene. This well is cited merely to show the thickness of Pleistocene overburden that may be expected along the lower course of Salem Creek and in low-lying lands near the Delaware.

A well at Moores Corner, about 1.2 miles south of the courthouse at Salem, shows the continuance of thick beds of marl along the strike, but it shows also the increase in overburden toward the southeast. The record follows:

Record of well of Frank Brown at locality 8, Moores Corner.

[Opposite fork and about 100 feet east of road. Elevation, about 11 feet; depth, 120 feet. C. C. Holladay, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
arse gravel	4	4	Pleistocene.
nd	3-4	8	Do.
llow clay	32±	40	Do.
eensand	25-30	70	Hornertown and Navesink.
ack sand, water bearing	50	120	Mount Laurel and Wenonah ?

New Jersey Geol. Survey Ann. Rept. for 1901, p. 105, 1902.

The data of holes 5 to 7 are summarized in the following table

Thickness and quality of greensand beds at holes 5 to 7, Woodstown.

Hole.	Bed.	Sample. No.	Sample. Thickness represented.	Sample. K₂O.	Thickness of bed.	Ave cont e K
			Ft. in.	*Per cent.*	*Ft. in.*	*Per*
5	Overburden	....	....	....	7 11	......
	Gray marl	M-9	12 9	6.48	12 9	
	Green marl	M-10	8 7	7.56	8 7	
	Chocolate marl	M-11	10 4	7.14	10 4	
6	Overburden	....	....	....	10	......
	Gray marl	M-12	8 4	5.74	11 10	b
		M-13	2 2	5.79		
		....	1 4	....		
	Green marl	M-14	3 2	6.98	18 2	
		M-15	5	7.88		
		M-16	4 7	7.80		
		M-17	5 5	7.76		
	Chocolate marl	M-18	3 6	7.56	5	
		M-19	1 6	2.92		
7	Overburden	....	....	....	12 6	......
	Gray marl	M-20	4 8	5.66	11 6	
		M-21	1	5.62		
		M-22	5 10	6.48		
	Green marl	M-23	2	7.37	8	c
		M-25	5 6	7.40		
		....	6	....		
	Chocolate marl	M-26	5	6.66	11	d
		M-27	9	4.74		
		....	3 3	....		
		M-28	2	6.57		
	Average: Overburden	....	....	....	10 2	......
	Gray marl	....	....	....	12	e
	Green marl	....	....	....	11 7	e
	Chocolate marl	....	....	....	8 9	e
					32 4	f

---

[a] Average for bed weighted according to the thicknesses represented by the respective samples.
[b] Average for 10 feet 6 inches.

Although the shell bed at the top of the Hornerstown is not present in this well it occurs in openings on Mr. Allen's property about 3,500 feet to the southwest. The thickness of the marl seems a little excessive, but the bed was reported as all greensand. Probably some of the glauconitic phase of the Vincentown is included.

A well drilled earlier probably not far from locality 15 shows a somewhat different record.

Record of well of Charles E. Allen, about 1 mile west of Woodstown.[a]

[On road to Sharptown. Elevation, about 50 feet; depth, 135 feet. Haines Bros., contractors.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Surface deposits, clay, gravel, etc	30	30	Pleistocene.
Light-colored sand	5	35	Kirkwood.
Black mud	15	50	Do.
Lime sand mixed with marl	15	65	Vincentown.
Greensand marl	35	100	Hornerstown and Navesink.
Sand and marl mixed	15	115	Mount Laurel and Wenonah.
Gray sand with water	20	135	Do.

[a] New Jersey Geol. Survey Ann. Rept. for 1901, p. 101, 1902.

Record of well of J. Gilbert Borton at locality 16, near Woodstown.

[About 0.21 mile beyond the borough limits of Woodstown, on west side of road to Auburn. Elevation, about 55 feet; diameter, 4½ inches; depth, 75 feet. Chalkley Haines, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Soil	1	1	Recent.
Clay	11	12	Pleistocene.
Yellow sand and gravel	3	15	Do.
Marl with greenish clay, blacker near bottom	30	45	Hornerstown and Navesink.
Gray sand fairly uniform	30	75	Mount Laurel and Wenonah.

Record of well of William Cole at locality 17, near Woodstown.

[About 0.53 mile north of borough limits of Woodstown, on west side of road to Auburn. Elevation, about 68 feet; depth, 30 feet. Chalkley Haines, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Dug well	20	20	Pleistocene (?) and Cretaceous.
Marl	10	30	Hornerstown and Navesink.
Gray sand	....	....	Mount Laurel and Wenonah.

The overburden at locality 17 is probably slight, and most of the well is in greensand marl.

The following notes on the deep wells supplying water to the borough of Woodstown, which were kindly furnished by Dr. Twitchell,[11] of the State Survey, will be of interest to any company that pr commercial development of the greensands:

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[11] Twitchell, M. W., unpublished manuscript.

> The town supply of Woodstown, Salem County, is drawn in part from si near the bank of the creek at an elevation of about 20 feet and varying from 149 feet in depth. The average flow of each well from the top of the casing, 1 foot the surface, is about 60 gallons per minute; temperature 58°. The wells dra the Mount Laurel-Wenonah sands, which were water-bearing from 60 to 1 below sea level. A seventh well at this point was prospected to 776 feet. bearing sands were found at the top of the Magothy-Raritan formation from 276 feet below sea level and also near the bottom of the series at 756 feet below sea Between these two horizons an alternating series of sands and white and red was found, all of which apparently belong to the Raritan and Magothy form which here have a thickness of 480 feet, with base not reached. The water feet (276 feet below sea level) rose within 14 feet of the surface, and that fr feet (756 feet below sea level) within 18 feet. In 1915 a new well was driven to a of 340 feet, which drew upon the upper horizon in the Magothy-Raritan at 31 The yield of this deep well on pumping is 300 gallons per minute, and it has fore proved an important addition to the town supply.

Available records of the 340-foot well differ somewhat, but th lowing, taken from a letter in the files of the State Geological Su checks fairly well with the samples now preserved at the pun station and kindly shown to the writer by Mr. Oren Conover engineer.

Record of well of Borough of Woodstown at locality 18.

[Elevation, about 20 feet; depth, 340 feet. Haines & Hollinshead, drillers.]

	Thickness.	Depth.	Formatio
	Feet.	*Feet.*	
Meadow mud and gravel	15	15	Quaternary.
Limestone	10	25	Vincentown.
Green marl	40	65	Hornerstow Navesink.

r town wells. This water rises within 16 feet of the surface. The other a depth of 360 feet and draws from a water-bearing sand at the top of the 270 to 310 feet below sea level; the water rises within about 50 feet of the sur- he Englishtown sand was found at a depth of 190 to 210 feet (140 to 160 feet a level) and was slightly water-bearing.

evident, therefore, that at Woodstown four water horizons have been recog- wo of which are utilized—in the Mount Laurel-Wenonah sand at 50 or 60 feet a level, in the Englishtown sand at 140 feet below sea level, at the top of the -Raritan beds at 270 to 276 feet below sea level, and in the Raritan beds at below sea level.

ugh the Vincentown occurs here and is covered by a layer of Kirkwood clay, reported as water-bearing.

ollowing is the detailed section for the deepest well near the depot. Notes ossils found in this boring were published in the annual report for 1901, page e statement that *Belemnitella* was found at 240 to 250 feet in the Woodbury ded as of doubtful accuracy, as this form has never been reported from any utcrops of the Woodbury.

Record of well of Woodstown Ice & Cold Storage Co. at locality 19.

[Elevation, 50 feet; diameter, 6 inches; depth, 360 feet. Haines Bros., contractors.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
d yellow clay	25	25	Pleistocene.
y	5	30	Kirkwood.
l with Foraminifera	10	40	Vincentown.
r containing *Gryphaea*, *Terebratula*, and other fossils.	10	50	Hornerstown and Navesink.
nsand marl, very dark	30	80	Do.
een greensand marl, mixed with light-gray clay; s *Belemnites* at about 90 feet.	10	90	Do.
layey, dull yellowish-gray sand, about one-third nd, two-thirds whitish quartz sand, with *Belem-* d molluscan fossils.	45	135	Mount Laurel and Wenonah.
l white clear sand; resembles pepper and salt mix- *lemnitella*, *Terebratula*, and other fossils, etc.	25	160	Do.
e last two divisions, from 100 to 160 feet, are largely bearing throughout and supply wells Nos. 1 and 2.)			
eensand with molluscan fossils	10	170	Marshalltown.
ly clay; large admixture of white quartz sand with er proportion of greensand; contains mollusks, nifera, and other fossils, same as Marshalltown.	20	190	Do.
gray sand, consisting of white quartz and green- ins, the former predominating. This stratum was water bearing but was not utilized. These speci- ntained mollusks, Foraminifera, etc.	20	210	Englishtown.
y slightly greenish micaceous clay with very little nd. *Gryphaea* and *Belemnitella* at 240 to 250 feet.	40	250	Woodbury.
er, almost black micaceous clay with yellowish between 270 and 290 feet. No fossils observed.	40	290	Do.
greenish clay; contains at 290 to 300 feet some an fossils similar to fossils at Lenola, but different ose observed in the overlying beds. Nodules at 10 feet.	40	330	Merchantville.
coarse gray or bluish-white sand, abundantly earing; supplies well No. 3.	30	360	Magothy and Raritan.

the above section the dip of the water-bearing formations from their outcrop ows: Mount Laurel-Wenonah sand 28 to 30 feet; Englishtown 34 feet; Magothy- 38½ feet.

his well, as at the borough wells, the entire thickness of the sand marl is penetrated, and 10 feet of the lime-sand phase Vincentown is represented.

A well about 1 mile southeast of Auburn, on the road to Woodstown, furnishes the following record:

Record of well of Benjamin Cheesman at locality 20, near Auburn.

[Elevation, 100 feet; depth, 301 feet. Water rises within 100 feet of surface. Haines Bros., drillers.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Surface soil	2	2	[Quaternary and Tertiary.]
Clay and gravel	4	6	
Orange-colored sand, "molding sand"	8	14	
"Bullhead" boulder on green clay marl	1	15	
Light olive-colored greensand marl	10	25	[Hornerstown and Navesink ?]
Clay, gravel, and greensand mixed, dark olive color	10	35	
Lighter olive-colored greensand consisting of whitish quartz grains and glauconite grains.	10	45	
Reddish-yellow quartzose sand with a few greensand grains.	50	95	[Mount Laurel and Wenonah.]
Sandy, marly clay; a few greensand grains	20	115	
Reddish-yellow sand, same as above	10	125	
Olive-green clay and sand, white and red-stained quartz grains, and some glauconite grains.	20	145	[Marshalltown to Merchantville ?]
Gravelly conglomeratic mixture of whitish quartz grains and dark-blue mineral grains (vivianite); teeth and vertebra of shark.	10	155	
White sand and running black mud	25	180	
Dark clay marl, micaceous	87	267	
Medium sand, very slightly olive colored	23	290	[Magothy and Raritan ?]
Coarser sand, bluish white, with water	10	300	
Red and white mottled clay; colored water blood-red	1	301	

[a] New Jersey Geol. Survey Ann. Rept. for 1896, pp. 127-128, 1897.

The interpretation of this record is not very clear because of the general distribution of quartzose material. Some of this material from higher beds may have become mixed in drilling with material of lower beds. There seems to be, however, 30 feet of greensand marl overlain by 15 feet of overburden. This locality is about 2 miles from Point Airy railroad station and about 1 mile from Oldmans Creek, which, according to the map, seems large enough to

Record of well of Thomas McAllister at locality 22, Sharptown.

bout half a mile N. 29° W. from upper bridge over Salem Creek, east of road. Elevation, about 52 feet; depth, 155 feet. C. C. Holladay, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
oil and clay	20	20	Quaternary.
ed sand	30	50	Kirkwood?
ine sand	20	70	Hornerstown and Navesink.
reen marl	30	100	
hell marl	10	110	Mount Laurel and Wenonah.
uicksand	45	155	

The city wells (locality 18) and those of the Ice & Cold Storage Co. locality 19) lie in the Vincentown belt southeast of the greensand marl. The thickness of the greensand penetrated by these wells, 50 feet, may therefore be regarded as the maximum thickness for the district. The holes bored by the cooperating surveys (localities 12–14) lie within the greensand belt, near its margin, and show somewhat lower thicknesses, averaging 35 feet. In consideration of the thicknesses at the Sharptown wells (localities 21 and 22; 31 and 40 feet, respectively), this average seems a little low and may indicate a considerable erosion of the greensand at localities 12–14.

OTHER DATA.

Marl was formerly dug on the north side of Salem Creek about 0.15 mile west of the borough limits. This locality was considered as a drilling site for the present work but was given up because of the thickness of the overburden above the upper beds of marl.

Along Nihomus Run about 1.5 miles northwest of Woodstown (locality 23) the marl was formerly dug and used by many people. The following section was then exposed:[12]

Section of marl beds on Nihomus Run.

	Feet.
Yellow lime sand and yellow limestone	9
Shells	4–6
Green marl	15
Chocolate marl.	

These pits are not now operated, and they lie too far from the railroad to be commercially attractive.

At Oldmans Creek, about 3.5 miles from Woodstown, below the bridge on the road between Point Airy and Harrisonville, the lime sand is exposed in an old pit now largely filled with water. This locality is cited by Cook[13] as a place where the lime sand was well exposed and commonly dug.

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[12] Cook, G. H., Geology of New Jersey, p. 272, 1868; New Jersey Geol. Survey Ann. Rept. for 1886, p. 79, 1887.

[13] Cook, G. H., Geology of New Jersey, p. 273, 1868.

LIME SAND.

As shown on the map the lime sand beds on Nihomus Run within about a quarter of a mile of the railroad. At that plac should be somewhat thicker than at the pits farther down the because they are farther back down the dip. They have dou been somewhat eroded, but the three measurements given at mus Run and in the wells at localities 18 and 19 show that a ness of 10 feet or more of lime sand may be expected at Woods No data regarding its quality are available, but inferences m drawn from its former rather extensive use. The deposits on Creek are crossed by the railroad and are probably the most a ble. At the city wells (locality 18) the lime sand is covered feet of overburden.

ESTIMATES OF TONNAGE AND VALUE.

The average thickness of the greensand marl in the 2.5-acre as indicated on page 34, is about 32 feet. The average potash co weighted according to the thicknesses represented by the resp samples, is 6.80 per cent. In computing this average the thick employed for holes 6 and 7 were those of which the respective sa were considered representative, as indicated in the records of holes. Thus in the 2.5-acre tract a bed of greensand 32 feet thic containing 6.80 per cent of potash (K_2O) may be assumed. as in the estimates for the Salem district, the weight of a cubi of greensand, 28 per cent being allowed for voids, is assumed 133 pounds. Under these conditions an acre at the selecte would contain $\frac{43,560 \times 32 \times 133 \times 0.068}{2,000} = 6,300$ tons of potash (and the 2.5 acres would contain 15,750 tons. On the assun he overburden in the sample area averages about 10 feet in thick- s. Farther east it is undoubtedly thicker. To the west the over- den is irregularly distributed, and its thickness would have to be ermined for any given locality but should not be excessive within area mapped as greensand.

he analyses show that the higher and lowermost beds have some- at less potash than the middle beds but that practically all are ble. Water stands in the holes within a few feet of the surface l would have to be considered in any plan for mining the green- d.

he railroad offers at present the most feasible means of transpor- ion. The map shows several sites that could be utilized along railroad from Woodstown northward toward Swedesboro.

alem Creek below Courses Landing and the canal to the Delaware now used by barges for general freighting. Between Courses nding and Sharptown the creek is shallower but might perhaps be d by boats or scows of lighter draft. The hills south of the creek l west of Sharptown apparently afford good thicknesses of marl hin reach of water transportation.

MULLICA HILL.

he steep bluff just east of the railroad station at Mullica Hill cality 24) has long been known for its excellent exposure of the al bed of the Navesink marl and for its numerous fossils. The tion (see Pl. VI, *B*) is as follows:

Section of Navesink marl near station at Mullica Hill.

	Feet.
Greensand marl, loose, dark green	7±
Shell bed with more or less coherent matrix of marl and quartz sand	3-4
Yellow sand	4
Reddish-brown sand to road level	15±
	30±

he two lower beds are overwashed with marl from above and are ce dark colored. The veneer of marl may be removed by scraping h the foot and the yellow sands (Mount Laurel) exposed. Many the shells are as much as 4 or 5 inches in diameter.

Marl was formerly dug at several places near Mullica Hill and was orably regarded, perhaps because of its relatively high content of sphoric acid, which, according to two analyses cited by Cook,[14] as high as 3.48 and 3.60 per cent. A sample taken by W. C. len on the Henry Edwards place, 2 miles southwest of Mullica

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ook, G. H., Geology of New Jersey, p. 437, 1868.

Hill, was analyzed in the laboratory of the United States Geol Survey and found to contain 7.15 per cent of potash. The gree at this locality is 5 feet or more thick and is overlain by 15 to 2 of clay and gravel.[15] In 1916 some 50 tons of marl was shipp experimental purposes from the pits of Mrs. E. B. Sharp (localit about 1.15 miles S. 64° E. of Mullica Hill station. The lime san occurs in the same vicinity.

Several localities near Mullica Hill and Jefferson station visited with the idea of selecting a drilling site, but the overb in places sufficiently near the railroad proved to be too thick t mit hope of commercial development.

SEWELL DISTRICT.

The pits near Sewell have long been known for their exc marl, which was used as a fertilizer. More recently it has been for experiments in extraction of potash. Excellent railroad fac are available, and there are extensive areas of relatively even g in which the overburden does not seem excessive. The actua drilled at Sewell included only 2.5 acres, but data for a numl localities within a radius of 3 or 4 miles of Sewell are availabl may conveniently be discussed in connection with the results borings of the cooperating surveys. These localities are the included in the Sewell district.

EDWARDS RUN.

Relatively recent observations by the State geologist on bra of Edwards Run 2 to 3 miles west of Sewell show the exp described below.

At locality 26 an old marl pit at an elevation of about 7

Section along road at locality 28.

	Feet.
Pleistocene gravel.	
Miocene clay, Kirkwood	2
Vincentown, more or less marly	5
Terebratula shell bed, elevation about 70 feet.	
Hornerstown marl down to flood plain	15±
	22±

These exposures are typical of the partial sections available here nd there through the marl belt.

BARNSBORO.

Several well records give an idea of the thickness of the marl and s overburden near Barnsboro.

Record of well of John Shutes, near Barnsboro.[a]

[Elevation, 120 feet; depth, 140 feet; water rises within about 50 feet of surface.]

	Thickness	Depth.	Formation.
	Feet.	*Feet.*	
hitish quicksand	55	55	[Kirkwood?]
ensand marl	35	90	[Hornerstown and Navesink.]
ocolate marl	15	105	
ell rock	2	107	
rk sand	10	117	[Mount Laurel and Wenonah.]
hite gravel with water	23	140	

[a] New Jersey Geol. Survey Ann. Rept. for 1896, p. 131, 1897.

Record of wells of Dilks Bros., locality 29, near Barnsboro.[a]

bout half a mile south of crossroads in Barnsboro; two wells; elevation, about 100 feet; depths, 110 and 170 feet. Haines Bros., drillers.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
rface soil	5	5	
range-colored sand	34	39	[Kirkwood?]
ark clay; "no greensand nor other microorganisms"	[b] 5	[b] 40	
ght-green marl	20	60	[Vincentown(?) to Navesink.]
usty green marl; lower 10 feet with coarser quartzose sand grains.	25	85	
ray sand with a few clay seams; *Belemnites* at 95 and 105 feet: abundance of water at 110 feet.	70	155	
uddy sandy clay	15	170	

[a] New Jersey Geol. Survey Ann. Rept. for 1896, p. 130, 1897.
[b] Record evidently erroneous.

J. L. North kindly furnished records for the wells of Charles Dilks nd Isaac Dilks, said to be 175 and 135 feet deep respectively. As e two records are similar only the first is given.

Record of well of Charles Dilks, at locality 29a, three-fourths of a mile south of Bo

	Thickness.	Depth.	Formati
	Feet.	*Feet.*	
Yellow fine molder's clay	40	40	Kirkwood (?
Marl	60	100	Vincentown esink (?)
Shale	5	105	
Black and white pepper sand	35	140	Mount Laure nonah.
Coarse green sand	35	175	

This record differs considerably from the previously pul record of the same well given above. It may be noted, ho that the *Belemnites*, a form characteristic of the basal part Navesink, which occurs at 105 feet in the first record, corres in position with the base of the shale in the second record, an in both records marl begins at 40 feet. Either the marl is unu thick or it includes a glauconitic portion of the Vincentown san

Record of well of Dr. W. P. Chalfont at locality 30, Barnsboro.

[Depth, 149 feet. J. L. North, driller and informant.]

	Thickness.	Depth.	Formati
	Feet.	*Feet.*	
Yellow gravel, very hard	28	28	Pleistocene.
Fine yellow quicksand	35	63	Kirkwood.
Marl and shale	50	113	Hornersto Navesink.
Hard shale	30	143	Mount La Wenonah (
Greensand; plenty of good water	6	149	

A well at locality 31, about a quarter of a mile farther west by J. L. North for James Tomlin, gave a similar record.

J. L. North furnishes the following record for the well of James Jessup. The discrepancy between the two records illustrates a difficulty sometimes experienced in trying to procure accurate well data. From either record it is evident, however, that greensand marl in commercial quantity is probably present.

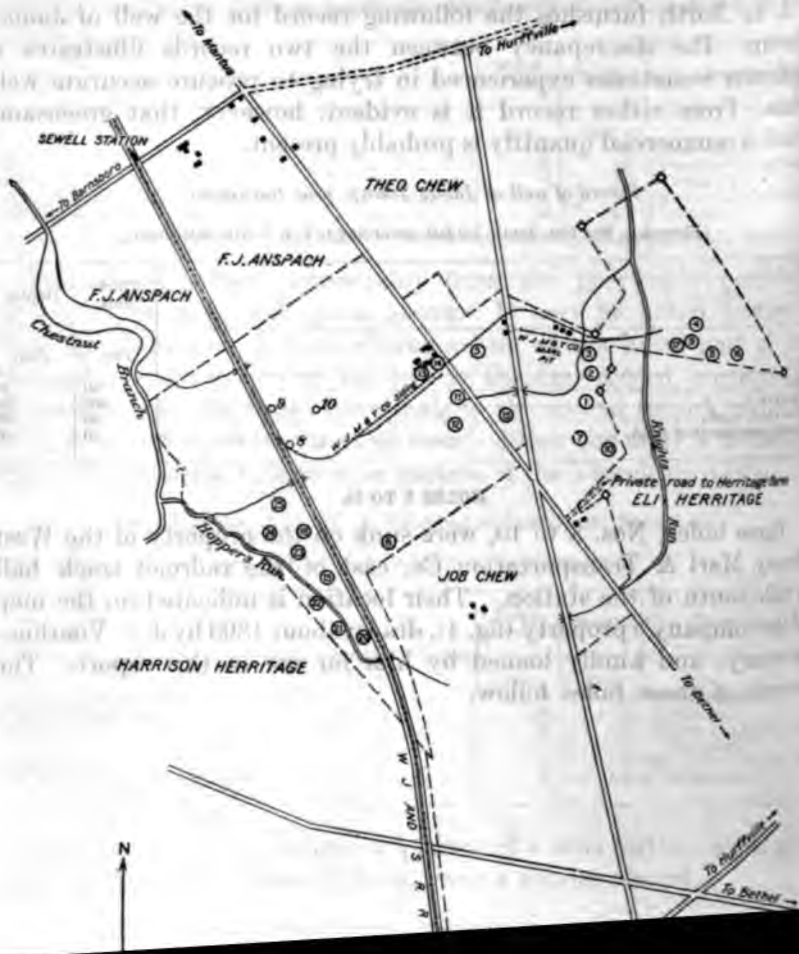
Record of well of James Jessup, near Barnsboro.

[Elevation, 90± feet; depth, 333 feet; according to J. L. North, informant.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	3	3
Marl	80	83
Black clay	200	283
Fine black sand	40	323
Coarse greenish-gray sand	10	333

HOLES 8 TO 10.

Three holes, Nos. 8 to 10, were sunk on the property of the West Jersey Marl & Transportation Co. east of the railroad track half a mile south of the station. Their location is indicated on the map of the company's property (fig. 4), drawn about 1890 by J. C. Voorhies, secretary, and kindly loaned by him for use in this report. The records of these holes follow.


To Mantua
To Hurffville
SEWELL STATION
To Barnsboro
THEO. CHEW
F. J. ANSPACH
F. J. ANSPACH
Chestnut Branch
W. J. M. & T. CO. MARL PIT
W. J. M. & T. CO. SIDING
9
10
5
Knights Run
Private road to Herritage farm
ELI HERRITAGE
Hoppers Run
JOB CHEW
HARRISON HERRITAGE
To Bethel
W. J. AND S. R. R.
N
To Hurffville
To Bethel

Records of holes in Sewell district.

Locality 23, hole 3.

Jersey Marl & Transportation Co., at Sewell, 2,750 feet southeast of center line of rail-
40 feet east of center of track. Elevation of surface, about 70 feet. R. K. Bailey, analyst.
J. L. North, drillers.]

	Thickness.		Depth.		Field No. of sample.	K₂O.	Formation.
	Ft.	*in.*	*Ft.*	*in.*		*Per cent.*	
sandy clay, with few pebbles.	1		1		....	....	Recent.
grayish buff at top, with a ebbles as much as 2 inches in r pebbles and deeper-yellow rt.	1		2		....	....	Pleistocene.
very clayey and micaceous, e ocher; finely bedded; white ccur in the yellow to deep aterial; water bearing at base.	8	10	10	10	....	....	Kirkwood.
grayish to olive green and		1	10	11			
quartz and glauconite........		2	11	1	M-29	3.54	Hornerstown.
rayish green, clayey..........		11	12				
ellow olive, very clayey......	2	4	14	4	M-30	4.54	Do.
live green, very clayey and llow specks of iron oxide. ected dry in driven cylinder; et in trough as check.		11	15	3	M-31 M-32	5.99 5.92	Do. Do.
very clayey, yellow olive; ontains considerable yellow	4	3	19	6	M-33	6.70	Do.
blackish to grayish green, e clay.	5	6	25		M-34	7.25	Do.
ke last (?)....................	1		26		M-35	7.40	Do.
stiff, with much light-green this interval became mixed llowish material by accident This interval therefore ex- ples.	1		27		....	....	Do.
upper part light green and 0 feet become more mealy in ger proportion of glauconite, ew pieces of shell. Sample re tool; M-36a, same interval, l wet as check.	5		32		M-36 M-36a	7.71 7.36	Do. Do.
milar to above, not sampled..	1		33		....	....	Navesink.
rownish black or chocolate- extured, one rounded pebble iameter noted.		6	33	6	M-37	6.36	Do.
rown, with some mingling of beds.		6	34		M-37a	7.62	Do.
chocolate-colored, with some green. Sample M-38 taken l; M-38a taken wet as check.	2		36		M-38 M-38a	6.41 6.18	Do. Do.
rownish to black, similar to ng.	5		41		M-39	6.88	Do.
similar to last but contain and an increasing proportion	2	3	43	3	M-40	5.59	Do.
black to grayish black; con- s quartz sand and the rice r no shell.	5	3	48	6	M-41	3.51	Do.
ke last......................		4	48	10	....	....	Do.
quartz sand, glauconite, and *ryphaea*, *Exogyra*, *Belemni-* of vivianite.		3	49	1	....	....	Do.

Locality 34, hole 9.

(Property of West Jersey Marl & Transportation Co. 326 feet N. 30° W. from hole 8. Elevation of s about 75 feet. R. K. Bailey analyst. J. L. North driller.)

	Thickness.		Depth.		Field No. of sample.	K₂O.	Formatio
	Ft.	in.	Ft.	in.		Per cent.	
Top soil, brownish fine clayey sand, fine texture.	1		1		....		Recent.
Sand, clayey, with scattered pebbles ½ inches in diameter, matrix very fine textured, with heavy red and yellow stain.		6	1	6	....		Pleistocene.
Sand, clayey like last, with scattered gravel grains.	1	10	3	4	....		Do.
Sand, clayey, very fine, micaceous, finely bedded, leafy texture, orange stained, with some white coarser sand collected in cracks.	2	7	5	11	....		Kirkwood.
Sand similar to last but light gray	2	4	8	3	....		Do.
Glauconite beds, yellowish olive, stiff clayey material, with considerable yellow oxide of iron.	1	8	9	11	M-42	4.97	Hornerstow
Glauconite beds, deep olive, stiff clayey, upper 6 inches oxidized like M-42, but remainder with uniform texture and color.	5		14	11	M-43	6.73	Do.
Glauconite bed like last		1	15		M-44	6.81	Do.
Glauconite beds, somewhat less clay, more mealy texture, some darker streaks and a few pockets of chocolate-colored clay.	2		17				
Glauconite beds, distinctly darker, more mealy texture, more nearly pure glauconite grains.		4	17	4			
Glauconite beds, dark green to bluish, mealy texture, water bearing in lower part.	5	2	22	6	M-45	7.43	Do.
Glauconite beds similar to M-45	4	2	26	8	M-46	7.90	Do.
Glauconite beds, chocolate marl, brownish gray with greenish tint, transition beds, considerable clay, with scattered ferruginous particles and ferruginous masses, probably tubes of decayed shells.	3	3	29	11	M-47	7.13	Navesink.
Glauconite beds similar to M-47 but without the greenish tint, somewhat more stiff clayey material.	5	9	35	8	M-48	6.74	Do.
Glauconite beds similar to M-48 but containing greenish streaks.	5	3	40	11	M-49	5.90	Do.
Glauconite beds similar to M-48		1	41		M-50	3.47	Do.
Glauconite beds similar to M-48 but containing considerable quartz sand and some small gravel.	2	7	43	7			
Glauconite beds like last but with pieces of shell and brown casts composed of phosphatic material. [illegible]		5	44				

Locality 35, hole 10.

West Jersey Marl & Transportation Co., about 375 feet N. 44° E. from hole 8. Elevation of surface about 60 feet. R. K. Bailey, analyst. J. L. North, driller.]

	Thickness.	Depth.	Field No. of sample.	K₂O.	Formation.
	Ft. in.	Ft. in.		Per cent.	
n loam	8	8	....	....	Recent.
t scattered pebbles in light-yellow layey sand, then darker-yellow with pebbles as large as 2 inches water bearing.	2 11	3 7	....	....	Pleistocene.
and gray banded, fine textured, micaceous, becoming purplish in es.	4 1	7 8	....	....	Kirkwood.
ds, blackish green, rather stiff no oxidized layer or olive- at holes 8 and 9. Three pebbles having probably followed down	1	8 8	M-51	3.83	Hornerstown.
ds, deep bluish to grayish green, n M-51.	6 4	15	M-52	6.60	Do.
ds, dark or grayish green, mealy nilar to M-52 but lower 6 inches	5	20	M-53	7.63	Do.
s similar to M-53	4 7	24 7	M-54	7.52	Do.
ds, chocolate marl, brownish some streaks of green material, texture but with considerable	6	25 1	M-55	6.85	Navesink.
s, chocolate marl	7 4	32 5	M-56	6.57	Do.
ds similar to M-56 but contain- rains of gravel, small marcasite and considerable brown clay.	3 3	35 8	M-57	6.90	Do.
ds similar to above but contain- s of shell, clay pellets, and some- proportions of gravel.	9	36 5			
ds becoming increasingly sandy. ist of glauconite with quartz sand, concretions, small fragments of ystals of vivianite.	1 2	37 7	....	....	Do.
s, compact, hard mixture of clay, l, and glauconite with gravel	2 5	40	....	....	Do.
s similar to above but somewhat gravel and quartz sand in in- portion.	2 7	42 7	....	....	Do.
ds similar to last but with frag- ll and pepper and salt color. At nts of *Belemnitella* appear.	5	43	....	....	Do.

BORINGS OF WEST JERSEY MARL & TRANSPORTATION CO.

Record of borings of West Jersey Marl & Transportation Co., near Sewell.

Locality.[a]	Over-burden.	Bank marl.	Green marl.	Locality.[a]	Over-burden.	Bank marl.	Green marl.
	Ft. in.	*Ft. in.*	*Ft. in.*		*Ft. in.*	*Ft. in.*	*Ft. in.*
1	14 0	12 6	8 0	15	12	12	7
2	18	9	7	16[b]	22	....	....
3	21	0	7	17	6	0	6
4	18	13	7	18	19	14	7
5	12	12	6	19	19	15	7
6[b]	21	....	....	20	6	11	7
7	15	14	7	21	9	12	7
8	21	10	6	22	8	4	7
9	12 6	9 6	7	23	5	5	7
10	16	13 6	7	24	5	5	7
11	10	11	7	25	16	14	7
12	16	12	7	Average	13 10	[c] 10 1	[c] 6 11
13	13	11	7				
14	12	12	7				

[a] Locality numbers refer to figure 4. [b] Did not reach marl. [c] Average for 23 localities.

These holes all stopped at or above the chocolate marl, which, because of its astringent qualities, was not considered desirable for agricultural use. The analyses of the chocolate marl at holes 8 to 10 show that it contains less potash than either the bank marl or the green marl but probably enough for commercial recovery by any process operative for the other two beds.

The average thickness of the overburden in the borings made by the company is nearly 2 feet greater than that for the 2.5-acre tract represented by holes 8 to 10, and that of the bank marl 1 foot 9 inches greater, but that for the green marl is nearly 4 feet less.

SEWELL MARL PIT.

The large pit belonging to the West Jersey Marl & Transportation Co. is shown in figure 4 and as locality 36 on Plate I. Much of the pit is now overgrown and more or less slumped, but marl has been dug at the northwest corner (see Pl. VIII, *B*), where the following section is exposed and available for sampling.

Section of pit of West Jersey Marl & Transportation Co., near Sewell (locality 36).

[R. K. Bailey, analyst.]

	Thickness.	Depth.	Field No. of sample.	K_2O.
	Ft. in.	*Ft. in.*		*Per cent.*
Old filling	5 9	5 9	....	....
Grayish-green (bank) marl	1	6 9	....	....
Grayish-green marl	4 9	11 6	M-59	7.64
Dark-green marl	1 6	13	M-61	7.89
Dark bluish-green marl	1	14	....	....
Dark bluish-green marl	6	14 6	M-60	7.88
Dark bluish-green marl	1	15 6	....	....
Dark chocolate-brown marl	6	16	M-62	6.73
General sample run of mine, blue to gray	....	....	M-63	7.80

The samples were collected as typical of the freshly dug ma of the respective kinds. The analyses run higher than the age of the analyses of samples of similar beds from holes 8 t though they are matched by analyses of individual samples those holes. Probably all the marl now dug in this pit corresp with the green marl at holes 8 to 10. None of the stiff, clayey c green marl found at those holes appears in the sampled part o pit.

The overburden at older exposures on the east and southeast of the pit is 12 to 15 feet thick and includes a little Kirkwood beneath the Pleistocene sand and gravel. Locally a thin bed of and gravel cemented with oxide of iron (ironstone) occurs ben the Pleistocene. Westward from the pit the overburden incr to 10 or 15 feet.

WELL DATA.

Several wells in the vicinity of Sewell give further data on thickness of the marl and the amount and character of the burden. They also indicate water-bearing beds, which migh of use to companies interested in developing the marl. The w is indebted to M. W. Twitchell for the following record of the w F. J. Anspach.

Record of well of F. J. Anspach, near Sewell (locality 37).

[On Chews Hill, east of the Mantua road. Elevation, 82 feet; depth, 432 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
[redacted]	[redacted]	[redacted]	[redacted]

The water at 405 to 420 feet is utilized and is reported as pure, soft, ad satisfactory in every respect. On pumping 40 gallons a minute e water stands at 77 feet below the surface.

The record shows 39 feet of the combined Hornerstown and Naveink marls beneath an overburden of 17 feet of gravel, sand, and clay.

Record of well of J. L. North, at Sewell (locality 38).

About 0.21 mile N. 76° E. of railroad station, in angle formed by two streets. Elevation, about 82 feet; depth, 336 feet. J. L. North, informant.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Coarse yellow sand	10	10	Pleistocene.
Fine yellow sand	30	40	Kirkwood (?).
Marl	38	78	Hornerstown and Navesink.
Shale, marly, with some shells	20	98	
Yellow gravel; very irony water	23	121	Mount Laurel and Wenonah.
Tough chocolate-colored clay	200	321	Marshalltown to Merchantville.
White quartz sand with considerable "hard coal" (glauconite?) about the size of buckwheat; water rose within 66 feet of surface.	15	336	Magothy (?).

The overburden at this well is 40 feet thick, and the marl apparently 58 feet thick.

A well sunk for George B. Hurff at locality 39, near the North well, shows a similar record.

The well of David T. Locke at locality 40, in the same general vicinity, shows a somewhat different record.

Record of well of David T. Locke, at Sewell (locality 40).

[J. L. North, driller and informant.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Greenland clay	25	25	Pleistocene (?).
Sand	10	35	Kirkwood (?).
Blue marl	25	60	Hornerstown and Navesink (?).
Chocolate-colored shale	11	71	
Greensand; plenty of water	14	85	Mount Laurel (?).

The "greenland clay" is probably reworked glauconitic material. The well may stop in the lower Navesink but probably stops in the top of the Mount Laurel. With these interpretations there would be 35 feet of overburden and nearly 50 feet of marl. If this location s correct the little knoll north of the well should be included in the reensand belt instead of with the pre-Navesink formations as apped.

A test well sunk near Sewell for the town of Woodbury gives a record interpreted by Twitchell as follows:

Record of well for town of Woodbury, near Sewell (locality 41).

[About three-fourths of a mile northeast of Sewell along strike of formations. Elevation, 13 feet (?); depth, 283 feet. Artesian Well Drilling Co., driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Meadow mud	12	12	Recent.
Sandy mud	63	75	Hornerstown and Navesink.
Fine sand	7	82	Mount Laurel and Wenonah.
Sticky clay	153	235	Marshalltown to Merchantville.
Medium sand	48	283	Magothy and Raritan.
Clay	....	....	

The town of Woodbury now has in this vicinity a group of eight 10-inch wells, according to J. L. North, who has kindly indicated their positions as shown on the map (Pl. I). As above interpreted the thickness of the overburden is not excessive, but the thickness of the marl is unusual.

The records and locations of the three following wells were furnished by J. L. North.

Record of well of John Schmidt, near Salina (locality 41a).

[Elevation, about 60 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Yellow sand	14	14	Kirkwood (?) and

Record of well of Thomas Burroughs, near Hurffville (locality 41b).

[Elevation, about 90 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Gravel	10	10	Pleistocene.
Yellow fine sand	50	60	Kirkwood.
Green marl	60	120	Vincentown(?) to Navesink.
Shale	4	124	
Gray sand	6	130	
Shale	2	132	
Green coarse rice gravel full of *Belemnites*	15	147	Mount Laurel and Wenonah.

This record corresponds fairly well with the preceding. The Vincentown is not distinguished but is probably present.

Record of well of Felix Behl, at Fairview (locality 41c).

[Elevation, about 125 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Coarse gravel	28	28	Pleistocene.
Yellow sand	35	63	Kirkwood (?).
Green marl	30	93	Hornerstown and Navesink.
Very fine black and white sand	40	133	Mount Laurel and Wenonah (?).
Green clay	23	156	
Hard shale	5	161	
Coarse white sand	14	175	

The formations are not clearly distinguishable from these records, but they indicate the continuity of the marl in considerable thickness, though the overburden is heavy.

Two wells at Pitman show the amount and character of the overburden and the thickness of the marl in that district.

Record of well in camp-meeting grounds at Pitman (locality 42).[a]

[About one-third of a mile southwest of railroad station, on nearly the lowest ground in the area, at west edge of grove. Elevation, 110 feet. Haines Bros., drillers.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Surface soil, etc.	10	10	[Quaternary.]
Orange-colored sand and sandy clay	60	70	[Tertiary.]
Dark clay, nearly black	10	80	
Bryozoan lime sand	20	100	[Vincentown.]
Greensand marl with Foraminifera and fragments of shell, probably *Terebratula*.	10	110	[Hornerstown and Navesink.
Greensand marl, less shell	10	120	
Clayey greensand	10	130	
Clayey sand	10	140	
Clayey marl, *Belemnites* and ponderous shells	10	150	
Yellowish sand with some clay, *Belemnites* and fragments of shell.	30	180	[Mount Laurel and Wenonah.]
Medium coarse clear sand with water	10	190	

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[a] New Jersey Geol. Survey Ann. Rept. for 1896, p. 128, 1897.

A well sunk for the town of Pitman on the east side of the railroad at locality 43, not far from the well just described, was drilled to a depth of 507 feet. For the first 190 feet its record was practically identical with the other.[16]

A third well drilled in the same general vicinity, for R. H. Corney, started at an elevation of 130 feet and penetrated bryozoan lime sand between depths of 115 and 125 feet. Greensand was found between depths of 125 and 160 feet, and coarse water-bearing gravels from 160 to 180 feet.[17]

These wells show that at Pitman lime sand 10 to 20 feet thick and greensand 35 to 50 feet thick lie beneath Tertiary and Quaternary deposits from 70 to 115 feet or more thick.

OTHER DATA.

The Kern pits, which lie on the east side of Chestnut Branch, about 1.5 miles above Sewell (locality 44), were visited in 1917 by Dr. Kümmel, from whose notes the following data were obtained. There is a very large opening, and the floor is overgrown with trees 6 inches or more in diameter. The bank is very high. Marl probably rises about 5 feet above the floor. Where the pit is most swampy the marl has 15 to 25 feet of overburden consisting of about 10 feet of yellow gravel, underlain by Kirkwood sand.

On the map of 1866 is shown a railroad running to these pits and marked "W. J. R. R." In the annual report of the State geologist for 1886, page 178, it is stated that "southeast of Barnsboro in Gloucester County, on the south branch of Mantua Creek, are important marl pits, one of which is worked by the West Jersey Marl Co. in a layer containing 12 feet of green marl."

In digging layers A, B, and C are thrown away. The base of layer D is the level of the uneven floor. Marl is dug in layer E, 8 feet below this level, but at the time when these observations were made only layer D was being taken. Near by was a worked out pit in layer E full of water. When visited in November, 1918, by Dr. Kümmel and the writer the Davis pit was inactive and badly slumped.

On the William Wenzell place, just west of Sewell, 10 feet of greensand is overlain by 8 to 10 feet of clay and gravel. A sample of the greensand collected by W. C. Phalen was analyzed in the laboratories of the United States Geological Survey and found to contain 7.09 per cent of potash.[18]

LIME SAND.

At locality 46, south of the road from Sewell to Barnsboro and west of the creek, there is an exposure of 3 to 4 feet of lime sand. At locality 47, near Hurffville, some old pits in the Vincentown sand were visited in 1915 by Dr. Kümmel, who found them slumped and overgrown. In a circular published in 1903 these pits were cited as a good locality, and in the annual report of the State geologist for 1886, page 178, a section measured at these pits showed 9 feet of lime sand and 13 feet of greensand marl. These two localities furnish the exposures of the lime sand nearest to Sewell. It probably underlies the surface from half a mile to a mile south of the West Jersey Marl & Transportation Co.'s pit, but the overburden is doubtless thicker than 15 feet. No data regarding the quality of this lime sand are available.

ESTIMATES OF TONNAGE AND VALUE.

From the data given on page 50, the average thickness of the marl in the 2.5-acre tract near Sewell may be taken as 34 feet and its average potash content as 6.50 per cent. On the assumption, as in previous estimates, that the weight of the greensand, 28 per cent being allowed for voids, is 133 pounds per cubic foot, an acre in the specified tract would contain $\frac{43{,}560 \times 34 \times 133 \times 0.065}{2{,}000} = 6{,}400$ tons of potash (K_2O), and the 2.5 acres would contain 16,000 tons. With an 80 per cent recovery and a price of $2.50 per unit of 20 pounds (March, 1920), the potash in a ton of greensand would be worth $13 and that in an acre of ground would be worth $1,280,000. At the more probable price of $1.50 per unit the same quantities of potash would be worth $7.80 and $768,000, respectively. The values given for the potash are purely hypothetical, as they are dependent

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[18] Ashley, G. H., Notes on the greensand deposits of the eastern United States: U. S. Geol. Survey Bull. 660, pp. 40, 47, 1918.

upon successful extraction of the potash by processes not ye
mercially demonstrated.

As previously explained, the marl beds are beveled off by
along the north boundary of the belt, but along the southeast
their thickness is probably as much as 50 feet. The well
and other data indicate that greensand marl is present, except
locally eroded, throughout the portion of the belt included
Sewell district and that it may be expected to maintain a
uniform thickness along the strike.

UTILIZATION OF THE DEPOSITS.

The thickness of the overburden in the 2.5-acre tract a
about 9 feet. At the borings made by the West Jersey
Transportation Co. the average thickness of the overburd
about 14 feet. Thus in the vicinity of Sewell there appear
considerable areas in which the overburden is less than 15 fe

There is no water transportation within suitable distanc
Sewell, but excellent railroad service is available. Possibly
Creek could be utilized below West Landing for the marl beds
a mile south of Mantua.

Marl of suitable quality is present in sufficient quantit
Sewell to justify large-scale operations and can be worked i
pits by steam shovels or other types of excavators. Water is
near the surface in Sewell as in some of the other localities
but would be encountered in handling the green and cho
colored beds.

The analyses show that the green marl contains about 1.5 p
more potash than the bank or chocolate marls but that all th
may probably be profitably worked by any extraction

The pits in this vicinity are now largely filled in and swampy. In 1918 the writer, with Dr. Kümmel, visited a locality about a quarter of a mile farther up the creek. Here, beneath 15 to 20 feet of Pleistocene sand and gravel, about 4 or 5 feet of lime sand overlies the greensand marl, about 5 feet above the level of the swamp. The shell bed is absent. According to data at the office of the State geologist good exposures of black greensand marl, representing 10 feet of the Hornerstown, occur at locality 49, about 1 mile northwest of Good Intent, beside the road.

The marl is exposed in the fields in the valley between Blackwood and Blenheim, close to the railroad. This might be a suitable place for commercial development, but the full thickness of the marl is probably not present. That the marl is present in considerable thickness at Blackwood is shown by the record of two wells sunk about 2,000 feet apart for F. Pine and H. Runkel. The localities of these wells are not given, but their records are very similar, except that the Pine well starts at a somewhat lower elevation and is a little deeper.[20] Its record, as furnished by M. W. Twitchell, is as follows:

Record of well of F. Pine at Blackwood.

[Elevation, 50 feet. F. E. McCann, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Sand	6	6	Pleistocene.
Red, heavy, stony gravel	10	16	
Gray marl	7	23	Hornerstown and Navesink.
Blue marl	5	28	
Chocolate-colored marl	32	60	
Pepper-and-salt gray sand	10	70	Mount Laurel and Wenonah.

A well sunk at Greenloch, about seven-eighths of a mile southeast of the Camden County asylum, gives the following record:

Record of well of S. R. Bateman (?), near Greenloch (locality 50).

[Elevation, 45 feet. J. L. North, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Dark-gray sand	22	22	Vincentown. (?)
Greenish marl; shells with *Terebratula harlani* near top	28	50	Hornerstown and Navesink.
Greenish marl	30	80	
Pepper-and-salt sand, about half glauconite	1	81	
Light-yellow sand and small shell fragments	23	104	Mount Laurel.
Coarse sand (⅛ to ¼ inch), shell fragments and *Belemnitella*	4	108	

The Pine well, which does not afford a complete section, shows 44 feet of marl. The Bateman well, which apparently gives a complete section, though the lower shell bed seems to be not w veloped, shows 59 feet of marl.

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[20] New Jersey Geol. Survey Ann. Rept. for 1901, p. 88, 1902.

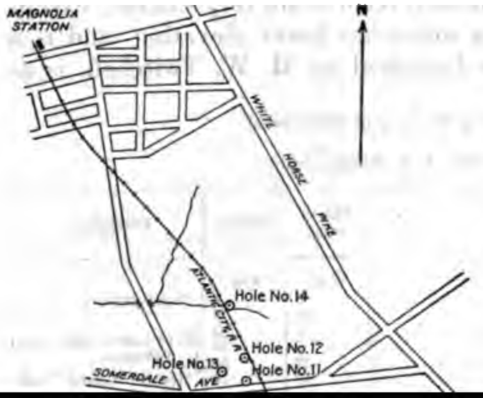
No recent data are available regarding the quality of the n Blackwood, but it is probable that other conditions being fav its quality would justify commercial development.

The lime sand occurs along the stream valleys above Black as shown on the map. Dr. Kümmel notes a good exposure o locality 51, by the road at the pumping station, about half northwest of Greenloch, where it consists of a mass of Bryozo other fossils and is covered by a reddish clayey residual soil.

A well at Asyla, half a mile northwest of Greenloch, shows 35 greensand, including the *Terebratula* bed, beneath 5 feet of s soil that contains occasional fragments of lime-sand rock.[21]

SOMERDALE DISTRICT.

SELECTION OF SITES.



In the vicinity of erdale, in Camden C the greensand marl pies a rather broad as shown on the ma II), and the overbur apparently not exc The Atlantic City Ra (Reading system) an Camden & Atlantic road (Pennsylvania tem) provide ex

Records of holes in Somerdale district.

Locality 52, hole 11.

omas McMichael, 50 feet north of Somerdale Avenue and 210 feet west of railroad at Somerdale
on. Elevation of surface, about 85 feet. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.	Depth.	Field No. of sample.	K$_2$O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
enish-yellow clayey sand, becoming wish and containing scattered peb-	1 4	1 4	....	....	Quaternary.
greenish to grayish drab, with scat- bles as large as 1 inch in diameter s of weathered glauconite. Toward er color, larger proportion of glau- re numerous pebbles.	1 5	2 9	....	....	Do.
beds with very stiff olive-colored clay d a few pebbles; red streaks of oxi- erial.	3	3	....	....	Do.
beds similar to above but with few if es; red streaks die out at base.	1 2	4 2	M-65	6.94	Hornerstown.
beds similar to M-65 but without the iron streaks. At base a pebble 3 liameter.	1 10	6	M-66	7.58	Do.
beds, olive-colored, clayey, less stiff somewhat mealy texture.	3 3	9 3	M-67	7.52	Do.
beds similar to M-67................	4 7	13 10	M-68	7.58	Do.
beds, a little less clayey, brownish- rial mingled with olive-green, be- re brownish at base.	2 9	16 7	M-69	6.74	Navesink.
beds similar to above, discarded in sing after driving.	1	17 7	....	....	Do.
beds, brownish drab with some in- ig of grayish-green and chocolate- reaks, consistency less stiff. A few gravel grains.	4 5	22	M-70	6.67	Do.
beds, lighter greenish drab, greenish late-colored streaks, white films sur- some of glauconite grains.	5	27	M-71	6.60	Do.
beds similar to above but mingled lying material in driving pipe and	1 6	28 6	....	....	Do.
beds, greenish drab, rice gravel and nd sufficiently abundant to suggest of formation.	3	31 6	M-72	5.12	Do.
beds becoming more sandy with glauconite and gravel in diminishing n.	5 3	36 9	....	....	Mount Laurel and Wenonah.

Locality 53, hole 12.

[Farm of Thomas McMichael, at Somerdale, 330 feet N. 2½° W. from hole 11. Elevation of surface, abo feet. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.	Depth.	Field No. of sample.	K_2O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
Top soil about 3 inches, then stiff olive-green glauconitic clay with rootlets worked by plow to depth of about	10	10	....	....	Quaternary.
Glauconite beds, olive-green, stiff, clayey, streaked with red iron-stained clay. Two pebbles noted at depths of 22 and 28 inches but rejected from sample, a few gravel grains included.	2 2	3 0	M-74	5.43	Do.
Glauconite beds, olive-green, stiff, clayey, with a few brownish streaks. A few gravel grains and one pebble noted.	3 3	6 3	M-75	7.32	Hornerstown.
Glauconite beds, yellowish olive-colored, somewhat mealy texture, yellowish sandy streaks, fine yellow powdery clay at base.	3 2	9 5	M-76	7.42	Do.
Glauconite beds, light chocolate-brown with mingling of green in upper 4 inches.	2 5	11 10	M-77	6.44	Navesink
Glauconite beds, drab to grayish green, firm, hard to drill, much clay but considerable percentage of black glauconite.	5	16 10	M-78	6.64	Do.
Glauconite beds, brownish to greenish drab, with irregular streaks of brown and green, somewhat mealy texture, much black glauconite.	5	21 10	M-79	6.57	Do.
Glauconite beds like last but with some grains of quartz and a few gravel grains at base.	3	24 10	M-80	6.12	Do.
Glauconite beds similar to M-79................	1 3	26 1			
Glauconite beds, sandy and hard to drill, a sort of hardpan; considerable quartz mixed with the glauconite; cementing clay chocolate-brown; becomes more sandy downward with abundant grains of rice gravel near base; no shells observed.	3	29 1	M-81	3.44	Do.

Locality 54, hole 13.

mas McMichael, Somerdale, 330 feet S. 87½° E. from center of line between holes 11 and 12. Elevation of surface, about 80 feet. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.	Depth.	Field No. of sample.	K₂O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
rnish drab, somewhat sandy clay sandy streaks, grading downward sh olive-colored glauconitic clay.	1 1	1 1	....	....	
eds, stiff, yellow to dark olive-col- ginto light green, with yellow and -stained streaks, somewhat mica- ontaining a few small pebbles and avel.	3	4 1	M-82	3.74	Quaternary. Do.
ds, light green, relatively free from e of iron, mealy texture, micaceous, e fine quartz (in part débris from ormation?).	1 5	5 6	M-83	3.51	Do.
ed with scattered quartz pebbles numerous downward, pebbles as ches in diameter, bed very compact.	1	6 6	....	....	Do.
eds, deep olive-colored, somewhat ture, some yellow iron-stained	4 6	11	M-84	7.45	Hornerstown.
eds, deep green or olive-colored, with somewhat mealy texture, treaks of yellow iron-stained clay, ebbles ½ inch in diameter and a few ns.	3 4	14 4	M-85	7.66	Do.
eds, brown, stiff, clayey, with reen material like preceding.	2 4	16 8	M-86	6.15	Navesink.
eds like M-86, of which 8 inches ertently included; sample repre- thickness of 4 feet 6 inches.	3 10	20 6	M-87	6.63	Do.
eds similar to preceding but with mingled green material.	6 6	27	M-88	6.55	Do.
eds, brown with green streaks, : grayish-white coatings on some of	3 6	30 6	M-89	6.70	Do.
eds, brownish drab, clayey, with ns as large as ½ inch in diameter and artz; bed hard and compact.	3 6	34	M-90	4.65	Do.
eds, blackish brown, clayey, with le quartz and grains of rice gravel, ½ inch in diameter noted.	4	34 4	....	....	Do.
layey, with rice gravel and some	2 8	37	....	....	Do.
what clayey, containing gravel wn clay at base. Hole dry at this	3 6	40 6	....	....	Mount Laurel and Wenonah.

Locality 55, hole 14.

omas McMichael, Somerdale, at culvert about one-fourth of a mile northwest of Somerdale tion, east of track and north of creek. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.	Depth.	Field No. of sample.	K₂O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
glauconitic, somewhat sandy, with ebbles; irregular red iron-stained	2 10	2 10	....	....	Quaternary.
lly called "red marl." Clay, red xide, glauconitic; contains gravel s as large as 1 inch in diameter; in- nch layer of stiff green glauconitic	8	3 6	M-91	4.22	Do.
arl," red with oxide of iron, glau- ins of quartz, a few small pebbles grains suggesting rice gravel.	1 11	5 5	M-92	2.96	Do.
, with some glauconite and much	2 5	7 10	....	....	Mount Laurel and Wenonah.
quartz, succeeded by reddish sand xide, water bearing.	1 2	9	....	....	

For comparison with other localities the data furnished by h
11 to 13 are summarized below.

Thickness and quality of greensand beds at holes 11 to 13, Somerdale.

Hole.	Bed.	Sample. No.	Thickness represented.	K_2O.	Thickness of bed.	Ave con
			Ft. in.	*Per cent.*	*Ft. in.*	*Per*
11	Overburden	....	....	....	3	......
	Green marl	M-65	1 2	6.94	10 10	
		M-66	1 10	7.58		
		M-67	3 3	7.52		
		M-68	4 7	7.58		
	Chocolate marl	M-69	2 9	6.74	17 8	
		....	1	....		
		M-70	4 5	6.67		
		M-71	5	6.60		
		....	1 6	....		
		M-72	3	5.12		
12	Overburden	....	....	....	10	......
	Green marl	M-74	2 2	5.43	8 7	
		M-75	3 3	7.32		
		M-76	3 2	7.42		
	Chocolate marl	M-77	2 5	6.44	16 8	
		M-78	5	6.64		
		M-79	5	6.57		
		M-80	4 3	6.12		
13	Overburden	....	....	....	1 1	......
		M-82	3	3.74	4 5	
		M-83	1 5	3.51		
	Green marl	M-84	4 6	7.45	7 10	
		M-85	3 4	7.66		
	Chocolate marl	M-86	2 4	6.15	19 8	
		M-87	3 10	6.63		
		M-88	6 6	6.55		
		M-89	3 6	6.70		
		M-90	3 6	4.65		
	Average: Overburden	....	....	....	3 1	......
	Green marl	....	....	....	9 1	
	Chocolate marl	....	....	....	18	
					27 1	

material appears to be a local deposit of Quaternary age which contains too little potash to be of commercial interest.

WELL DATA.

A number of wells sunk within a radius of 2 or 3 miles of Somerdale throw additional light on the thickness and character of the overburden and the thickness of the marl in the Somerdale district. At Magnolia a well drilled near the station[22] showed 4 feet of overburden consisting of yellow clay and sand succeeded by 32 feet of "blue" marl underlain by water-bearing sands and other strata to the depth of 91 feet. A well drilled for Walter Hunt[23] about three-quarters of a mile northwest of Kirkwood station (locality 56?), shows 50 feet of greensand marl beneath 44 feet of yellow quicksand, and a second well,[24] described as 1 mile south-southeast of the well just cited, shows 30 feet of "black mud" (greensand?) and 12 feet of green marl beneath 50 feet of yellow quicksand.

The well at the Stratford House, nearly midway between Kirkwood station and Stratford station and on nearly the highest ground, furnishes the following record:[25]

Record of well at Stratford House, near Kirkwood (locality 57).

[Elevation, 100 feet. Water rises within 51 feet of surface.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Dug well	33	33	[Tertiary?]
Fine yellow sand	8	41	
Coarse yellow sand	2	43	
Yellowish loamy gravel	3	46	
Yellowish clayey sand	2	48	
Green marly clay, very hard	7	55	[Hornerstown and Navesink.]
Black marly sand	3	58	
Green marly clay, very hard	13	71	
Black marly sand with water	5	76	
Green clayey marl, very sticky	4	80	
Limerock (?), very hard	2	82	
Brown marly clay, soft and sticky	4	86	
Black sand and gravel with water	3	89	
Hard stony conglomerate	2	91	
Light-green marly clay	2	93	
Sand in layers, softer and harder	7	100	[Mount Laurel and Wenonah.]

If the above record is properly interpreted there is 45 feet of marl beneath 48 feet of overburden.

At Laurel Springs a well drilled southwest of the railroad, near the millpond, for Joseph Eldridge[26] shows the following record:

---

[22] New Jersey Geol. Survey Ann. Rept. for 1894, p. 197, 1895.

[23] Idem for 1901, p. 86, 1902.

[24] Idem, p. 87.

[25] Idem for 1897, pp. 255-256, 1898.

[26] Idem for 1901, p. 88, 1902.

White sand, water bearing.			

The position of the base of the Navesink is not clear above section, but there seems to be at least 40 feet of mar 40 feet of overburden at this locality.

OTHER DATA.

From an old marl pit southwest of Laurel Springs, where sand was 10 to 12 feet thick and was overlain by 20 fee burden, W. C. Phalen collected a sample which was analy laboratory of the United States Geological Survey and contain 6.40 per cent of potash.[27]

A large marl pit at locality 59, on the west side of th track, about 0.6 mile N. 20° W. of Kirkwood station, was Dr. Kümmel, who observed the following section at the of the pit near the railroad:

Section at marl pit about 0.6 mile N. 20° W. of Kirkwood station (lo

[Elevation, about 58 feet.]

	Thi nes
	Fe
A. Greenish marly sandy clay, very tough	
B. Coarse greenish marly sand and fine gravel	
C. Marl exposed about 3 feet above floor of pit	

March, 1919. About 1.5 feet of greensand, corresponding with the green marl of holes 11 to 13, was exposed beneath an overburden of about 4 feet of sand, including a 6-inch gravel bed just above the marl. A sample representing 1 foot of fresh material, analyzed in the laboratories of the Geological Survey, showed a total potash content of 7.17 per cent.

LIME SAND.

As shown on the map, the lime-sand phase of the Vincentown formation is exposed in branches of Timber Creek, near Laurel Springs. Beds of indurated lime sand full of Bryozoa may be seen at locality 61, in the bed of the brook, below the bridge 1½ miles west of Clementon. Some material taken for experimental purposes from this locality is reported to have contained as much as 80 per cent of carbonate of lime. Above Laurel Springs the lime sand occurs in close proximity to the railroad.

ESTIMATES OF TONNAGE AND VALUE.

As stated on page 64, the average thickness of the marl bed in the 2.5-acre tract at Somerdale is 27 feet, and its average potash content is 6.66 per cent. On the assumption, as in previous estimates, of 28 per cent of voids and a weight of 133 pounds per cubic foot, the total potash in an acre of the 2.5-acre tract would amount approximately to $\frac{43,560\times27\times133\times0.0666}{2,000}=5,200$ tons. In the 2.5-acre tract the total potash would be about 13,000 tons.

With an 80 per cent recovery and a price of $2.50 per unit of 20 pounds (March, 1920) the potash in a ton of greensand would be worth $13.32 and in an acre of the specified tract it would be worth $1,040,000. At the more probable price of $1.50 per unit the same quantities of potash would be worth $7.99 and $624,000 respectively. As in the previous estimates the values given for the potash are hypothetical, being dependent on the extraction of the potash by processes whose success has not yet been commercially demonstrated.

UTILIZATION OF THE DEPOSITS.

The 2.5-acre tract at Somerdale station is part of a larger area of suitable size and of sufficient potash content to justify commercial exploitation. No water transportation is available, but the district is served by two railroads and lies only 9 or 10 miles from Delaware River at Camden.

At holes 11 to 13 the water level was not reached at a depth of 40 feet 6 inches, and the marl was dryer than at any of the other holes bored. Absence of water would doubtless be an advantage in ling and shipping.

Northwestward from these holes the thickness of the marl expected to diminish to zero along the general northwest bo of the belt indicated on the map (Pl. II). Along the sou boundary, as shown by the well records cited, a thickness of 4 feet may be expected, but the overburden also is probably thic

WINSLOW.

A well at Winslow, near Hammonton, in Camden County, the increase in depth of the marl beds in the direction of th In a distance of about 13 miles the top (?) of the Hornerstow has descended about 300 feet. This well was sunk about 18 is thought by Twitchell to be the first deep well in New Its record has been repeated in somewhat varying form in of the New Jersey Survey from 1868 (Cook) to 1890. Its as worked out by Knapp,[28] follows:

Record of well at Winslow.

	Thickness.
	Feet.
Surface earth dug away	5
Blue and black clay	15
Glass sand described as quicksand	95
Miocene clay described as hard black clay	35
Miocene sand described as quicksand	107
Brown clay described as hard black clay	43
Greensand marl shells, etc	20
Pure greensand, no fossils; "Water rose from the bottom of the greensand" [a]	15

[a] Cook, G. H., Geology of New Jersey, p. 291, 1868.

e field of Alphonso Fusco, at Elmwood Road station, about 1.8 east of Marlton, was selected for exploration because, so far as l be told from the map and the general appearance of the coun- it lies near the contact of Vincentown sand and Hornerstown ., so that a full thickness of greensand marl might be expected. overburden, too, was thought to be relatively thin.

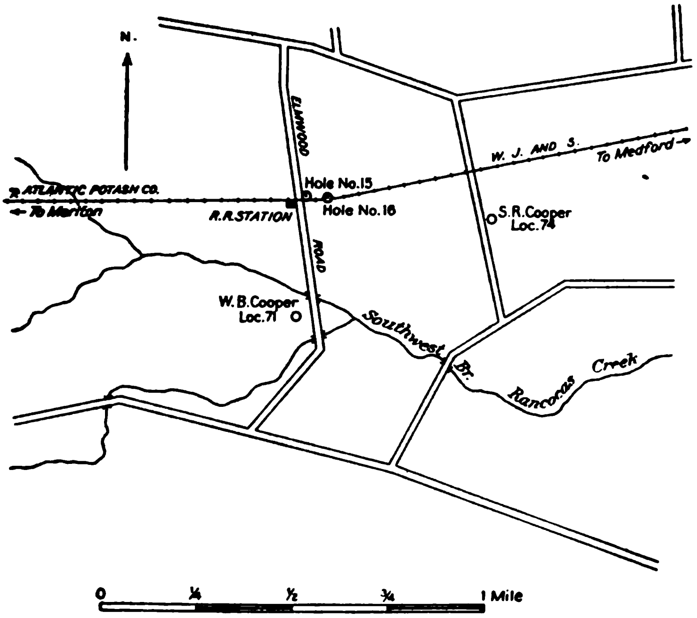


FIGURE 6.—Sketch map of part of the Marlton district, showing the location of holes 15 and 16.

HOLES 15 AND 16.

2.5-acre tract was laid out east of the road and north of the oad, and two holes were sunk 330 feet apart, as indicated in re 6. A third hole was planned, but the contract for drilling red before it could be started. The records of holes 15 and 16 w.

Records of holes in Marlton district.

Locality 62, hole 15.

[Farm of Alphonso Fusco, Elmwood Road, 65 feet N. 63° E. from center of railroad crossing just
station. Elevation of surface, about 65 feet. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.	Depth.	Field No. of sample.	K₂O.	Formatio
	Ft. in.	*Ft. in.*		*Per cent.*	
Soil, rather sandy, with some clay	6	6	....	....	Quaternary.
Sand, clayey, somewhat glauconitic, yellowish drab, becoming greenish yellow.	2 6	3	....	....	Do.
Sand, clayey, glauconitic, with some mica and a few pebbles (one angular granitic fragment ¾ inch in diameter noted), yellowish green, water bearing, hard at base.	8 6	11 6	....	....	Do.
Sand like last but with more gravel and pebbles; one pebble 2 inches in diameter; material hard and compact.	2	13 6	....	....	Do.
Glauconite beds, black, with considerable quartz, contain some lumps of yellow sandy clay and scattered pebbles; one subangular quartzite pebble 1½ inches in diameter; material runs like quicksand.	3 6	17	....	....	Do.
Glauconite beds, with fine quartz sand and dark greenish-drab clay; runs; some layers apparently more firm and form lumps with greasy feel; some layers dry, but sand as whole is water bearing.	5	22	M-98	4.82	Vincentown.
Glauconite beds, coarse grains, smaller proportion of clay, shell fragments, one or two casts poorly preserved, occasional nodules of hard gray and brown clay with included grains of glauconite, concretions of marcasite.	6 2	28 2	M-99	6.68	Hornerstown.
Glauconite beds similar to last but with more greenish tint, water bearing; material appears to be compact but when loosened is a runny glauconitic sand with fine grains and comparatively little clay. Poorly preserved coralline fossils and concretions.	5	33 2	M-100	7.33	Do.
Glauconite beds, greenish black, similar to M-100 but glauconite grains slightly coarser and there is somewhat more green clay; runs easily.	1 10	35	M-101	7.61	Do.
Glauconite beds like above, but shells are scattered through the material.	3 6	38 6			
Glauconite beds like M-100-101; material represents basal part of dark-green marl, runs easily.	1 11	40 5	M-102	7.55	Do.
Glauconite beds, chocolate-colored marl, glau-	4 10	45 3	M-103	6.30	Navesink.

Locality 63, hole 16.

)honso Fusco, Elmwood Road, 300 feet S. 32° E. from hole 15. Elevation of surface, about 61 feet. R. K. Bailey, analyst; S. J. Taylor, driller.]

	Thickness.		Depth.		Field No. of sample.	K_2O.	Formation.
	Ft.	*in.*	*Ft.*	*in.*		*Per cent.*	
clayey sand with some humus......	1		1		....	....	Quaternary.
r. yellow to yellowish-green........	1		2		....	....	Do.
nitic and sandy, green with yellow iron-stained clay. Lower 8 inches ater bearing, considerable quartz ebble noted at base.	4		6		M-109	3.19	Do.
, glauconitic, yellowish green........	1	8	7	6	....	....	Do.
y. dark grayish green; sand is prin- uartz but includes considerable ;, almost a quicksand. At 11 feet more firm, hard to drill. Propor- uconite increases with depth and becomes coarser, gravel grains through but disappear near base. mes greenish toward base.	8	4	15		....	....	Vincentown (?).
nitic and sandy, greenish gray to obably basal portion of Vincentown	3		19		M-110	5.68	Do.
beds, brownish gray to grayish- ll bed with casts of *Terebratula* and ns, nodules of marcasite, scattered rains of gravel as large as ½ inch in bed hard and compact.	3		22		M-111	6.58	Hornerstown.
beds, soft and runny with com- r little clay, but slightly micaceous, aks mingled with the brown give rk grayish color.	2		24				
beds, brown and green clayey ma- npact, fossil corals more or less re- glauconitic clay.	3	8	27	8	M-112	6.96	
beds, stiff clay layer in upper 2 feet, rt soft and runny, distinct dark color; a few grains of gravel, one inch in diameter, and a few shell noted; about 1 foot above base clay lighter green.	5	4	33		M-113	7.11	
beds similar to last, brown, clayey..	3		36		M-114	7.13	
beds, greenish, quartzose, gravelly, ring, casts of shells, small flakes		7	36	7			
beds, brownish, clayey..............		11	37	6			
beds, brown, clayey, probably d with chocolate marl of Sewell; nsiderable glauconite; one frag- hark tooth noted at about 40 feet.	10	1	47	7	M-115	6.84	Navesink.
beds similar to last................	10	5	58		M-116	6.36	
beds, brown, clayey, include small ments and a few grains of gravel.	3	4	61	4	M-117	6.58	
beds, shell fragments increase in rice gravel and fragments of *Belem-* ss clay, abundant glauconite, con- quartz, water bearing.	3	2	64	6	M-118	5.62	

The data furnished by holes 15 and 16 are summarized below:

Thickness and quality of greensand beds at holes 15 and 16, Elmwood Road.

Hole.	Bed.	Sample No.	Thickness represented.	K₂O.	Thickness of bed.	Average content of K₂O.[a]
			Ft. in.	*Per cent.*	*Ft. in.*	*Per cent.*
15	Overburden				17	
	Black marl	M-98	5	4.82	11 2	5.85
		M-99	6 2	6.68		
	Green marl	M-100	5	7.33	12 3	7.49
		M-101	5 4	7.61		
		M-102	1 11	7.55		
	Chocolate marl	M-103	4 10	6.30	29 3	6.16
		M-104	5	6.38		
		M-105	4 11	6.45		
		M-106	4 10	6.28		
		M-107	4 4	6.60		
		M-108	5 4	5.12		
16	Overburden				16	
	Black marl	M-110	3	5.68	8	6.24
		M-111	5	6.58		
	Green marl	M-112	3 8	6.86	13 6	[b] 7.06
		M-113	5 4	7.11		
		M-114	4 6	7.13		
	Chocolate marl	M-115	10 1	6.84	27	6.48
		M-116	10 5	6.36		
		M-117	3 4	6.58		
		M-118	3 2	5.62		
	Average:					
	Overburden				16 6	
	Black marl				9 7	[c] 6.01
	Green marl				12 11	[c] 7.26
	Chocolate marl				28 2	[c] 6.32
					50 8	[d] 6.50

[a] Average for bed weighted according to the thicknesses represented by the respective samples.
[b] Includes 11 inches of chocolate marl.
[c] Average for the bed in the 2.5-acre tract weighted according to its thickness at the respective holes.
[d] Average of entire thickness of marl in the 2.5-acre tract.

As shown in the above table, the maximum thickness of the over-arl has a maximum thickness of 13 feet 6 inches, averages 12 feet l inches, and contains 7.26 per cent of potash. The chocolate arl has a maximum thickness of 29 feet 3 inches, averages 28 feet inches, and contains 6.32 per cent of potash. The entire bed rerages 50 feet 8 inches or, for purposes of computation, say 50 et in thickness and contains 6.50 per cent of potash.

WELL DATA.

Numerous wells sunk within a radius of 2 or 3 miles of Marlton arve to check the thickness and continuity of the marl and show the eneral thickness of the overburden in the district. At locality 64, hich is on relatively high ground midway between Marlton and shland and southeast of the marl belt as mapped, there is 50 feet f greensand beneath 81 feet of overburden, as shown in the following ecord:[29]

Record of well of S. C. Gardiner, about 2.5 miles southwest of Marlton, on road to Ashland (locality 64).

[Elevation, 147 feet. W. C. Barr, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
ug well	40	40	[Quaternary?]
ellow quicksand	35	75	
ravel and coarse sand mixed	6	81	
reen marl	20	101	[Hornerstown and Navesink.]
hocolate marl	30	131	
and with water	6	137	[Mount Laurel and Wenonah.]

Three wells at Marlton show considerable thicknesses of marl, but hey also show a rather thick overburden.

Record of well of H. B. Dunphey, at Marlton (locality 65).[a]

[Elevation, 105 feet. W. C. Barr, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
op soil, yellow loam and gravel	18	18	Pleistocene.
lack marl	14	32	[Hornerstown and Navesink.]
reen marl	9	41	
hocolate marl, with white shell, probably *Gryphaea*	29	70	
ray sand with irony water	12	82	[Mount Laurel and Wenonah.]
lack sand	40	122	
lack clay	72	194	[Marshalltown.]
ine white sand with good water	6	200	[Englishtown.]

[a] New Jersey Geol. Survey Ann. Rept. for 1895, p. 69, 1896.

If the black marl beneath the gravel is considered part of the ornerstown there is a thickness of 52 feet of marl beneath an overburden of 18 feet. The records of the well at locality 66 an hole 16 suggest that this black marl may perhaps more properl assigned to the Kirkwood or the Vincentown.

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[29] New Jersey Geol. Survey Ann. Rept. for 1896, p. 143, 1897.

Record of well at waterworks, Marlton (locality 66).[a]

[About 0.6 mile south of railroad station. Elevation, 115 feet(?). A. G. Dunphey, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Soil	9	9	[Quaternary?]
Yellow gravel	5	14	
Yellow quicksand	15	29	[Kirkwood?]
Black mud	20	49	
Marl	25	74	[Hornerstown an Navesink.]
Brown mud (chocolate marl?)	19	93	
Mud and shell	3	96	
Gray sand with abundance of water, somewhat irony	10	106	[Mount Laurel an Wenonah.]
White sand	1	107	
Black sand	1	108	
Whitish or gray sand	17	125	
Black sandy mud	(30)	(155)?	
Black clay at	(30)	(185)?	[Marshalltown?]
Black muddy sand	(11)	(196)?	
Sandy marl	(12)	(208)?	
Light-colored sand	(4)	(212)?	[Englishtown?]
Yellowish-white sand with satisfactory water.			

[a] New Jersey Geol. Survey Ann. Rept. for 1897, pp. 259-260, 1898.

Here there is 47 feet of marl beneath 49 feet of overburden.

The writer is indebted to M. W. Twitchell for the following rec and interpretation of the neighboring well of T. R. Wills:

Record of well of T. R. Wills, near Marlton (locality 67).

[Five-eighths of a mile south of Marlton. Elevation, 100 feet. A. G. Dunphey, driller.]

	Thickness.	Depth.	Formation.

this locality the top of the Hornerstown is not present, but is 46 feet of greensand beneath 36 feet of overburden, consisting irkwood sand.

well sunk for Joseph Evans, about 1.5 miles southeast of Marlton, ishes the following record:

Record of well of Joseph Evans, 1.5 miles southeast of Marlton (locality 68).[a]

[Elevation, 129 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
l	20	20	[Kirkwood ?]
k loam or marl	50	70	
l	14	84	[Vincentown ?]
t	9	93	
n marl	27	120	[Hornerstown and Navesink ?]
l	27	147	
t of oyster and other shells	2	149	
te sand with water	6	155	[Mount Laurel-Wenonah.]

New Jersey Geol. Survey Ann. Rept. for 1894, pp. 214-215, 1895.

If the writer's interpretation of the above record is correct there 54 feet of greensand marl beneath 93 feet of overburden. The rust" at a depth of 84 feet is thought to be the more massive lime-d phase of the Vincentown, but it may represent the shell bed at top of the Hornerstown. The shell bed at a depth of 147 feet is bably the base of the Navesink.

Record of well of J. W. Barr, about 2 miles east of Marlton (locality 69).[a]

[Elevation, 70 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
and green clay	10	10	[Quaternary.]
e sand and gravel	10	20	
k and green marl	14	34	[Hornerstown and Navesink.]
olate marl	30	64	
crust with *Belemnitella*	4	68	
, water bearing	....	....	[Mount Laurel and Wenonah].

ew Jersey Geol. Survey Ann. Rept. for 1894, p. 209, 1895.

The upper shell bed is not present at this locality, but beneath 20 t of clay, sand, and gravel there is 48 feet of greensand marl, luding the lower shell bed.

he records of a number of other wells in the vicinity of Marlton, ar as they relate to the marl and its overburden, are summarized he following table.

[illegible] wells near *Marlton.*

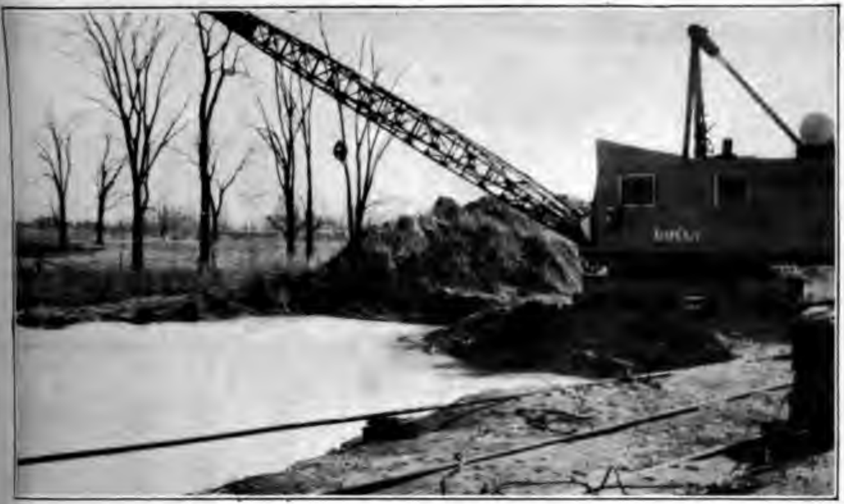
[illegible]	[illegible]	[illegible]	[illegible]	Marl.	Driller.
			Feet.	Feet.	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	A. G. Dunphey.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	W. C. Barr.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Stoothoff Bros.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	J. W. Barr.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	A. G. Dunphey.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	W. C. Barr.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Do.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			[illegible]	[illegible]	

[illegible]

[illegible] of these wells are not available, [illegible] miles of Marlton and mostly to the east or southeast. [illegible] boundary of the marl belt and show an average thickness of about [illegible] feet of marl beneath about [illegible] feet of [illegible] which, in several of the wells, consists in part of [illegible] sands.

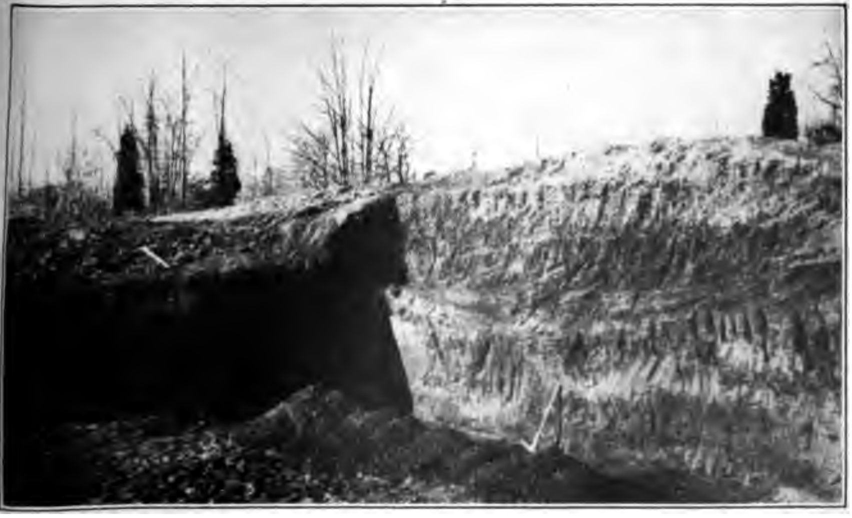
OTHER DATA.

Some of the marl exposed in plowed fields and along roads near Marlton is [illegible] age that might readily be mistaken for marl in place. For example, at locality 75, between Marlton and [illegible] noted in 1915 a good exposure of [illegible] a bed of yellow iron-stained gravel also about 2 feet thick. In the old marl pits in that vicinity



A. DREDGE, PIT, AND STOCK PILE OF ATLANTIC POTASH CORPORATION ABOUT 1.1 MILES EAST OF MARLTON, BURLINGTON COUNTY, N. J.

Note abundance of water in pit.



B. RECENT DIGGING AT NORTHWEST CORNER OF WEST JERSEY MARL & TRANSPORTATION CO.'S MARL PIT NEAR SEWELL, GLOUCESTER COUNTY, N. J.

pit was filled with water. In September, 1917, fresh surfaces were exposed and Dr. Kümmel measured the following section:

Section at pit of Atlantic Potash Co., 1.1 miles east of Marlton (locality 77).

	Feet.
Sandy clay and gravel	3-5
Yellow bed, *Gryphaea* shells, iron stained and more or less decomposed	2-2½
White unaltered shells, 80 per cent *Gryphaea*, some *Terebratula harlani*; upper contact very sharp and approximately horizontal.	½-1
Dark greenish-black marl, exposed	6-7
	15½

It was stated that 40 feet of marl had been dug here without reaching bottom, and that about 13 feet from the top the marl became a little more greenish.

The condition of the pit in March, 1919, is shown in Plate VIII, A. Determinations of the weight of the marl per cubic foot were made on relatively fresh run of mine material, as described on pages 19-20. A sample of this material analyzed at the Survey laboratories contained 7.63 per cent of potash (K_2O).

LIME SAND.

The lime sand does not come to the surface in the Marlton district, but it is penetrated in a number of wells in the eastern and southeastern parts of the district. The map shows its probable distribution northeastward from a place about 1 mile southeast of Marlton, where it emerges from beneath Tertiary beds but is still concealed by Quaternary deposits.

ESTIMATES OF TONNAGE AND VALUE.

In the 2.5-acre tract at Elmwood Road station the thickness of the marl is about 50 feet and its potash content 6.50 per cent. On the assumptions, as in previous estimates, of 28 per cent of voids and a weight of 133 pounds per cubic foot, 1 acre of this tract would contain $\frac{43{,}560 \times 50 \times 133 \times 0.065}{2{,}000} = 9{,}400$ tons of potash (K_2O) and the 2.5-acre tract would contain 23,500 tons.

With an 80 per cent recovery and a price of $2.50 per unit of 20 pounds (March, 1920) the potash in a ton of greensand would be worth $13 and the potash in an acre of this tract would be worth $1,880,000. At the more probable price of $1.50 per unit the potash in a ton of greensand would be worth $7.80 and the potash in an acre of the ground would be worth $1,128,000. These estimates of value have no relation to the present value of the land, as they are dependent upon the extraction of the potash by processes whose successful operation has not been commercially demonstrated.

UTILIZATION OF THE DEPOSITS.

The 2.5-acre tract is part of a tract large enough for comn development and lies on a railroad that gives direct access to ware River at Camden, about 16 miles distant.

At holes 15 and 16 and at the Atlantic Potash Co.'s pits rises within a few feet of the surface and will need to be cons in any plan for exploitation of the marl.

Along the southeast boundary of the marl belt a thickn about 50 feet of marl may be expected, but the overburden i tively thick, being about 17.5 feet in the 2.5-acre tract. streams have removed some of the overburden, as in the vicir the Atlantic Potash Co.'s pits, the marl will be more accessible

MEDFORD DISTRICT.

MARL LOCALITIES.

The Medford district merges with the Marlton district o west and is discussed separately only for convenience in the p tation of data. At Medford the Manasquan marl underli surface sand and gravel, but to the south, east, and northea Kirkwood is found. The Manasquan forms a belt extending 4 miles southwest of Medford, but the marl is only locally ex It was formerly dug here and there, as at locality 78, about southwest of the town. This locality was visited by Dr. K in September, 1917, when he found the pits entirely grown u trees and no marl visible. The marl was deeply buried by sand and must have lain 12 to 15 feet below the surface.

Just north of Medford the Vincentown sand forms a belt a

Record of well of J. S. Wills, near Medford (locality 79).

[Elevation, 63 (?) feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
	2	2	Kirkwood.
nd	3	5	
l with greensand grains	10	15	
nd with greensand grains	8	23	
narl		30	Manasquan.
rl		35	
raminifera, Bryozoa		50	Vincentown.
th shells (*Gryphaea* and *Terebratula*)		70	Hornerstown and Navesink.
d, dark		76	
d, light		80	
d, dark		91	
d, chocolate-colored		104	
d, dark green		120	
th greensand grains and shell, etc., *Exogyra* *tes*.		124	Mount Laurel and Wenonah.
l water		126	

cord shows a thickness of about 54 feet of Hornerstown and marl beneath an overburden of 70 feet; but included in urden are about 20 feet of Manasquan marl and 20 feet of wn sand.

farm of I. W. Stokes (locality 80), about 1 mile northeast of a well was sunk in the midst of the Hornerstown and Navebelt. This shows 15 feet of overburden and 30 feet of marl, rcial quantity. The following record and interpretation ied by Dr. Twitchell:

Record of well of I. W. Stokes, near Medford (locality 80).

[Elevation, 78 feet. Stotthoff Bros., drillers.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
h	15	15	
	30	45	Hornerstown and Navesink.
	15	60	Mount Laurel and Wenonah.
	4	64	
nd (water irony)	6	70	
	15	85	
nd	25	110	
	12	122	Marshalltown.
	35	157	
ratum) at		170	
y	5	175	Englishtown.
y (water good)	2	177	
	6	183	

At the Eayrestown School, about 1.2 miles northeast c town, a well was sunk, which, according to the State Su furnishes the following record:

Record of well at Eayrestown School (locality 81).

[Elevation, about 45 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Fo
	Feet.	*Feet.*	
Yellow sand	5	5	Quater
Brown and yellowish sandy loam	15	20	
Black marl, "gunpowder"	20	40	Horner Nave
Dark-green marl	10	50	
Hardpan, limestone	1	51	
Fine greenish sand, water	10	61	Mount Weno
Hardpan, "concrete"	1	62	
White sand, water	14	76	

The overburden at this site is relatively thick (20 feet). is 31 feet thick and from the descriptive terms used is pr good quality. In view of the thickness shown it is probabl marl extends farther northwest than is shown on the map.

R. S. RYAN CO.'S PIT.

The pit of the R. S. Ryan Co., which formerly belonged t Rogers, of Medford, is at Reeves station, about 2 miles nort ford (locality 82), and is now the site of a plant for the ext potash from greensand marl. (See Pl. IX, *A*.) At the n of the pit the following section was observed in March, 191

Section at pit of R. S. Ryan Co., at Reeves station (locality 82).

C. PIT AT FARMINGDALE, MONMOUTH COUNTY, N. J.

ormerly owned and operated by Squankum Marl Co.; now owned by D. Mahoney. View northwest showing present overgrown and flooded condition.

inner southward and is only about 6 inches thick at the south end the pit. At that place the shells are missing, and the ironstone includes pebbles. Thus the ironstone appears to cut across the pper beds of the marl at a faint angle, rising toward the north.

The layer from which the sample analyzed came is in the upper part of the Hornerstown marl. Comparison with the borings previously described would indicate that marl of better quality would be found a few feet lower.

LIME SAND.

The Vincentown sand with its lime-sand phase is reported in the logs of some of the wells already cited. In this district it is exposed only in the pit at locality 83, on Haynes Creek about 0.4 mile southeast of the R. S. Ryan Co.'s pit just described, with which it is connected by a tramway. The lime-sand pit also belongs to the R. S. Ryan Co., and the lime sand is used with the greensand in the process of potash extraction.

The exposure shows about 8 feet of lime and quartz sand with hard, cemented masses of lime sand 6 inches to 1 foot thick, irregularly distributed through it. There are also large bodies of dark-greenish clay, grading into sand and here and there containing small masses of limestone. Clay bodies 10 feet or more long and 2 or 3 feet thick lie near the base of the cut. A random sample of the loose lime sand analyzed in the Survey laboratory contained 35 per cent of carbonate of lime ($CaCO_3$), and a similar sample of the harder limestone phase contained 74 per cent. The analysis of the harder sample gave 52 per cent of lime (CaO), of which only about 32 per cent is in the carbonate form. The excess lime, 20 per cent, is probably present as phosphate, for a qualitative test shows a strong reaction for phosphoric acid. Some iron is also present and may be combined with carbon dioxide (CO_2). The loose lime sand contains only a small excess of lime. The presence of phosphate of lime in the lime sand may account for its irregular consolidation and also in part for its beneficial action in agriculture.

VINCENTOWN.

Vincentown lies partly in the area of the Manasquan marl and partly in that of the Vincentown sand. Both marl and lime sand have been dug near the town, but these formations are only locally exposed.

WELL DATA.

A few wells sunk near Vincentown give an idea of the amount and character of the overburden and of the thickness of the lime sand and marl beds. The well of William J. Irick, about a mile west of

Vincentown, penetrates the Navesink marl and shows the succession of overlying beds. Its record follows:

Record of well of William J. Irick, about 1 mile west of Vincentown (locality 84).[a]

[Elevation, 30 feet. A. G. Dunphey, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Yellow gravel	3	3	[Quaternary.]
Orange-colored sand and fine gravel	6	9	
Yellowish sand with a few greensand grains	9	18	[Vincentown.]
Yellowish lime sand with plentiful Bryozoa	7	25	
Ash-colored lime sand with very few Bryozoa	19	44	
Grayish greensand with numerous Foraminifera, Bryozoa wanting	5	49	
Dark greensand with *Terebratula harlani* and *Gryphaea*	1	50	[Hornerstown and Navesink.]
Lighter-colored greensand; no fossils	20	70	
Very dark colored greensand	31	101	
Grayish greensand with fossils, including *Gryphaea* and *Belemnitella*	3	104	
Grayish greensand with *Belemnites*	5	109	Mount Laurel ?).

Here beneath an overburden of 18 feet of sand and gravel, including probably the upper bed of the Vincentown, there are 31 feet of lime sand and 55 feet of greensand marl, including both shell beds.

A well sunk at Richard Ridgway's farm, south of Vincentown, shows, as reported, some 90 feet of marl beneath 12 feet of overburden. Its record follows:

Record of well of Richard Ridgway, about 1.75 miles south of Vincentown (locality 85).[a]

[Elevation, about 40 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Formation.

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[a] New Jersey Geol. Survey Ann. Rept. for 1901, p. 71.

well of Edward Blackley, at locality 86, near that of Richard ,y, shows a similar record but was sunk to a depth of 135 feet. iller reports that the oyster shells were not so plentiful and little black muck was penetrated before reaching the sand, vas of a gray color.

well of Henry I. Budd,[20] described as 2 miles south of Birming- probably within 2 miles of Vincentown and somewhat north- the strike of the beds at the two wells last mentioned. At ld well the base of the Navesink is struck at the depth of 140 ts record follows.

Record of well of Henry I. Budd, 2 miles south of Birmingham.

[Elevation, 50 feet.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
clay	7	7	
y	62	69	
tone	2	71	
	1	72	[Vincentown?]
	1	73	
	2	75	
	1	76	
	3	79	
	1	80	
	2	82	
	1	83	
	2	85	
	1	86	
	3	89	
	10	99	
Gryphaea and *Terebratula*	6	105	[Hornerstown and Navesink.]
l and marl	10	115	
marl	23	138	
mnites	2	140	
ite sand with water	3	143	[Mount Laurel and Wenonah.]

ıis well the position of the top of the Hornerstown is clearly ed by the *Terebratula*-bearing bed, and the combined Horners- ınd Navesink beds are thus 41 feet thick. The alternating ıd crust layers above this bed are suggestive of the lime-sand ıestone phases of the Vincentown, which under this interpre- would be 28 feet thick. The 62 feet of "sticky marl" is ly too thick to represent only the Manasquan marl and may) the lower and more clayey portion of the Kirkwood. The ne, however, suggests unconformity, so that the Manasquan ; absent.

MARL PITS.

ocality 87, about 1 mile south of Vincentown, on the property J. Clifford Haines, Dr. Kümmel observed, in September, 1917,

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ersey Geol. Survey Ann. Rept. for 1896, p. 143, 1897.

a freshly dug pit with vertical walls in which the following section was exposed:

Section at marl pit of Dr. J. Clifford Haines, 1 mile south of Vincentown (locality 87).

	Feet.
Sand and gravel	5
Crusty marl	1
Gray to black marl	3-4
Water level.	
	10

Other exposures in the neighborhood showed 10 to 12 feet of stripping.

In the early eighties, according to data on file at the New Jersey Geological Survey, the pits of the Vincentown Marl Co., which were near the Haines pit, showed an overburden of 6 feet of yellow and white sand and gravel resting on 15 to 20 feet of marl, gray above and black below.

At locality 88, on the opposite side of the creek from locality 87, Dr. Kümmel observed, in September, 1917, several small openings that had been made within the preceding few years. There were piles of light ash-colored marl at an elevation of about 40 feet, and the pits showed 7 or 8 feet of sand and gravel overlying 3 to 4 feet of light yellowish-green marl blotched with clayey pellets. The pits were filled with water.

The pits on the H. J. Budd estate, at locality 89, about 1½ miles east of Vincentown, were visited by Dr. Kümmel in September, 1917. No marl had been dug there for 20 years, and there were no exposures, but according to John W. Rose, who used to dig marl there, *Section of Vincentown sand on Rancocas Creek, near Vincentown (locality 90).*

	Ft.	In.
Brown sand and humus		6
Yellow and white sand and marl	2–4	
Red sand		6
Lime sand, cemented in some places and full of *Eschara*	7–9	
Limestone	10	
	24	

In the spring of 1919 interest in the lime sand at Vincentown was vived, and some of the material was reported as being dug for ricultural lime.

BIRMINGHAM AND PEMBERTON.

HOFFMAN PIT.

William Hoffman owns a large pit at Birmingham (locality 91), m which he makes occasional shipments. (See Pl. IX, *B*.) e following section was exposed in January, 1919:

Section at William Hoffman's marl pit, at Birmingham (locality 91).

	Ft.	In.
Sand with some pebbles	6	
Light-green clay locally at contact		1–2
Marl, grayish, with some dark irregular masses including gray spots and specks	2–3	
Marl, black, grading irregularly into overlying layer	3	6
Marl, black, dark greenish tint	1	6
	14	2

Mr. Hoffman states that the marl about 14 feet below the top is en and that he stops digging at that depth on account of water. sample representing an average of 10 feet of greensand from this , taken by W. C. Phalen in 1917 and analyzed in the Survey labo-ory, contained 7.07 per cent of potash (K_2O).[32]

A well sunk for Mr. Harper at locality 92, a short distance south the Hoffman pit, shows the thickness of the marl and the amount overburden that may be expected. Its record follows:

ord of Harper well, about 0.33 mile N. 24° W. of Birmingham station (locality 92).

[Elevation, about 30 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
and gravel	15	15	Quaternary.
stone, very hard	2	17	
-gray to dark-green marl	33	50	Hornerstown and Navesink.
sandstone formation (indurated marl?)	10	60	
er and clam shells, "lignite," coral reef, etc	10	70	
, brown sand, white sand	20	90	Mount Laurel and Wenonah.
n clay	5	95	

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shley, G. H., op. cit., p. 47.

About half a mile east of Birmingham station the
Edmunds Co. has operated a sand-washing plant for a
years. The sand is taken from the company's prope
includes about half a square mile south of the creek and
station. So much sand has been removed that the overb
much of that area has been greatly reduced. The property
in the belt of Vincentown sand, but the creek has cut throu
marl about 0.2 mile east of the station, and near the west
the property the Vincentown sand should not be very thi

Men and tools were kindly supplied by the company for e
and three attempts were made to reach the marl in the
localities 94 and 95, but each attempt was unsuccessful
the gravelly nature of the overburden and the nearness
the surface. The marl was not reached at depths of 3 or

In the southeastern part of the property two holes, Nos.
were sunk, respectively, at localities 96 and 97 in the Manas
and samples for analysis were taken. The character
content of the material are shown in the table below.

Two attempts were made to sink a third hole by th
locality 98, but these were abandoned at depths of 3 or 4 f
of the gravelly nature of the overburden and the abundan

Records of holes at sand pits of Norcross & Edmunds Co.

Locality 96, hole 17.

[About 0.75 mile southeast of Birmingham station and about 375 feet northwest of culvert
Pemberton. Elevation of present surface, about 50 feet. Analyst, E. T. Eric

	Thickness.	Depth.	Field No. of sample.	K_2O.

Locality 97, hole 18.

[About 330 feet north of hole 17. Elevation of surface, about 50 feet. Analyst, E. T. Erickson.]

	Thickness.	Depth.	Field. No. of sample.	K₂O.	Formation.
	Ft. in.	*Ft. in.*		*Per cent.*	
Gravel and sand	8	8			Pleistocene.
Glauconite beds, thin alternating leafy layers of drab fine sandy clay and greenish glauconitic clay. Random sample taken at depth of 9 feet considered representative of entire bed. Lower 6 to 8 inches a little darker and more clayey.	14 4	15	M-120	3.27	Do.
Glauconite beds, clayey, dark greenish gray	2 10	17 10	M-121	2.75	Manasquan.
Glauconite beds, light greenish gray, with grains of lime and lumps of vivianite. Lumps are irregular in shape and rough in feel. The bed has much clay and considerable glauconite but appears quite limy with dark glauconite streaks. At base a hard layer that could not be penetrated with auger. Top of Vincentown(?). Water stands in hole about 3 feet below surface.	1 8	19 6	M-122	1.83	Do.

At locality 99, in the same general vicinity, a hole 10 to 15 feet quare and perhaps 10 feet deep, now filled with water, had been ecently dug in the Vincentown sand. No greensand appeared on he dump, but incoherent lime sand with some pieces of cemented mestone formed the bulk of the pile. Bryozoa were very numerous. 'ortions of the material were strongly cemented with iron oxide, nd much vivianite was scattered over the dump in bluish radiating rystalline masses, in crusts, and in concretionary forms. Evidently he hole had missed the Manasquan marl and had not been dug deep nough to strike the Hornerstown.

From the vicinity of this hole westward and northward to the raiload the lime sand should be relatively near the surface and in suffiient quantity to be a commercial source in the event of any exploitaion of greensand marl in the district. No analyses of this material re available, but from its appearance in the dump near the hole and n débris along some of the ditches cut by the company it seems prob-.ble that this lime sand will compare favorably in content of carbon-.te of lime with that from locality 83, near Reeves station, which is tilized by the R. S. Ryan Co.

The Norcross & Edmunds Co. also owns ground between Rancocas reek and the road east of the tributary that enters the creek about .6 mile southeast of South Pemberton station. Through the courtesy f the company a hole, No. 19, was sunk at locality 100, in the northestern part of this property. There are numerous old marl pits in he vicinity, and some recent pits with equipment for digging. A ite was selected near one of the recent pits where most of the overurden had been removed, and samples for analysis were collected, shown in the following record.

Record of hole 19, at locality 100.

[On property of Norcross & Edmunds Co. about 4,200 feet S. 65° E. from South Pemberton st
of old and recent marl pits. Elevation of present surface, about 36 feet. Analyst, E. T

	Thickness.	Depth.	Field No. of sample.	K_2O.	F
	Ft. in.	*Ft. in.*		*Per cent.*	
Soil and gravel at level of former working	1	1	....	....	Pleis
Glauconite beds, dark grayish green, somewhat clayey, fine textured, rather mealy.	5	6	M-123	4.29	Man
Glauconite beds, lighter green, stiff, clayey; contain considerable quartz in fine grains, greasy feel and appearance on smooth surface.	2	8	M-124	2.99	I
Glauconite beds similar to last but with more quartz and somewhat mealy texture; irregular streaks of lighter and darker constituents.	3 10	11 10			
Glauconite beds, darker green, larger percentage of glauconite due to larger number of thin beds of fine-textured glauconite.	6	12 4			
Glauconite beds, dark green, thin bedded, with numerous layers of fine glauconitic material; at base a stiff green clay.	3 8	16	M-125	4.61	I

The overburden at the hole was only 1 foot thick, but
of the hole was about 3 feet below the level of the adjoining
to the northeast. The marl was not penetrated at the depth
16 feet.

The analyses of the marl from holes 17 to 19 indicate
portion of the Manasquan represented by them is distinctl
in potash content to the Hornerstown and Navesink marls
minations of the water-soluble potash of the samples fr
holes showed either none or a mere trace.

Composite samples from these holes were tested for thei
of lime (CaO) and of phosphoric acid (P_2O_5), with the resu
in the following table:

OTHER DATA.

At North Pemberton a well sunk near the station for Peter Cosgrove's creamery furnishes the following record:

Record of well at Peter Cosgrove's creamery, North Pemberton (locality 101).

[Elevation, about 35 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
g well	15	15	Manasquan and Vincentown(?).
rk-green marl	65	80	
ells, very hard	2	82	Hornerstown and Navesink (?).
arsegreensand and quartz	6	88	
een marl, "lignite" (=glauconite)	18	106	
ck micaceous clay	20	126	
rd shells	6	132	
arse white quartz	10	142	Mount Laurel and Wenonah.

The 65 feet of green marl in the upper part of this well is rather rd to interpret. The Vincentown locally contains much greensand d at some places, as at hole 16 (locality 63), might be called a eensand marl. The lime-sand phase does not appear to have been ognized here and may be absent, in which event the Manasquan d Vincentown might together form the "green marl." The two ell beds give rather definitely the position of the combined Horrstown and Navesink beds, and, allowing for the dip, the lower ell bed is at about the right depth to correspond with its position localities 92 and 93. With this interpretation the combined rnerstown and Navesink marls would be 52 feet thick.

At locality 102, near South Pemberton, are some old pits now ergrown. According to data on file at the State Survey, the llowing section was formerly exposed here:

tion exposed in the early eighties at marl pits near South Pemberton (locality 102).

	Feet.
Humus and black sand	1
Yellow sand and gravel	3
Reddish-brown sand	1½
White, black, and yellow sand and gravel	1½
Marl with scattered shark teeth	18
	24½

At locality 103, about 2 miles northeast of Pemberton, are some rl pits from which Ivins Horner made small shipments in 1914. is locality was visited by Dr. Kümmel in September, 1917, when observed the following section:

Section at pits of Ivins Horner, 2 miles northeast of Pemberton (locality 103).

	Feet.
Stripping	3-4
Gray marl	2-2½
Green marl	10
	16¼

The marl pits occupy 2 or 3 acres dug over in rows. A
area can be opened to the south without much increase in stri
The bottom of the marl was not reached, but the green n
said to be 18 feet thick.

A sample of marl taken by W. C. Phalen from one of th
was analyzed in the laboratory of the Geological Survey and
to contain 4.22 per cent of potash. A second sample taken
a bed where the greensand was 12 to 14 feet thick and the
burden 8 to 10 feet thick contained 4.74 per cent of potash.[33]

SUMMARY.

Near Birmingham there are several places in proximity to th
road where Hornerstown and Navesink marl of suitable quali
be obtained in commercial quantities without too much overb
Lime sand is also accessible near the railroad between Birmi
and Pemberton. The Manasquan marl near Pemberton is appa
18 feet or more thick but so far as examined carries less
than the Hornerstown and Navesink marls. The presence of
amounts of lime and phosphoric acid (P_2O_5) probably explai
former popularity in agricultural use. The overburden is
thick except along stream courses.

The available data do not warrant the formulation of s
tonnage estimates for the potash content of the areas describe

OTHER AREAS.

Although no further boring was done than that described
records and fairly recent data bearing on the thickness an
tinuity of the marl are available for several other areas
eastward into Monmouth County. These are given below.

railroad traverses the marl belt southeast of Jobstown and affords able transportation facilities. The overburden in the higher ls along the railroad is probably excessive, but along the stream rses more favorable sites for exploitation may be expected. example, a site near the stream and railroad crossings below ustown (Ellis station) would probably give a maximum of marl ı a minimum of overburden. The lime sand occurs at Juliustown is not well exposed.

SYKESVILLE.

ı the vicinity of Sykesville the Hornerstown and Navesink ls become separated by the Redbank sand. A well sunk for Newbold Black estate at locality 104(?), about 1 mile north of esville, shows 15 feet of Navesink marl beneath 35 feet of gray 1.

t locality 105, about halfway between Sykesville and Georgetown, ell sunk for D. C. Kalback on timber land at an elevation of about feet penetrated the base of the Navesink marl at a depth of about eet. No specific record of this well is available, but material g on the dump consisted chiefly of Navesink marl and Redbank 1 with apparently a very good representation of the Navesink.

WRIGHTSTOWN.

.t locality 106, about 0.9 mile north of Wrightstown station, a well k for Ellis (Robert?) Crowshaw furnishes the following record:

Record of well of Ellis Crowshaw near Wrightstown (locality 106).

[Elevation, about 160 feet. S. J. Taylor, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
hard yellowish clay and gravel	15	15	[Quaternary and Tertiary.].
sand, "something like Englishtown"	5	20	
concrete formation, sandstone	10	30	[Vincentown?]
dark bluish marl and shells	20	50	[Hornorstown and Navesink.]
green sand, shelly marls	40	90	
dark greenish marl, shells	20	110	
gray sand, shells, hardpan containing *Belemnitella*, erlain by dry black micaceous clay; water.	20	130	[Mount Laurel.]

he overburden here is 30 feet thick, of which the 10 feet of "hard crete" may represent the limestone or lime-sand phase of the centown. The marl appears to be 80 feet thick but may include s assignable to the Redbank sand. The sand with *Belemnitella* ndoubtedly Mount Laurel.

n January 18, 1918, two wells were being drilled at an elevation bout 120 feet at locality 107, on the bank of the creek about e-eighths of a mile northwest of the station at Wrightstown.

At that date one well was 130 feet deep and the other 320 feet. definite record was kept, but Dr. Kümmel's inquiries elicite following data:

Records of two wells about 0.38 mile N. 64° W. of Wrightstown station (locality

	Thickness.
	Feet.
Soil, flood-plain deposits, etc	9
Marl	101
Shell bed, *Exogyra*, *Belemnitella*	2
Greenish quartz sand with more or less marl	13
Other beds	195

Dr. Kümmel notes that the shell bed is undoubtedly the ba the Navesink marl. He thinks that part of what is reported as is Vincentown sand. The Kirkwood sand appears in the side s of the valley above the wells. From a contact of Navesink Mount Laurel 3 miles away Dr. Kümmel estimates the dip he 38 to 40 feet to the mile.

JACOBSTOWN.

At locality 108, along the road about 1.4 miles east of Jacobst the shell bed at the top of the Hornerstown is exposed in the st bed north of the road. A considerable acreage of comparat even ground with probably moderate overburden and with practi the full thickness of the Hornerstown marl is here avail Unfortunately the site is about 1½ miles from the nearest rai shipping point, New Egypt.

At locality 109, about 1.1 miles farther northeast, on the roa county line, the shell bed at the top of the Hornerstown is exp

Record of well of water company at New Egypt.

[Elevation, 75 feet; Pfeiffer, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
rl	112	112	[Vincentown to Navesink.]
d	8	120	[Mount Laurel to Marshalltown?]
rl	98	218	
k quartz sand	20	238	[Englishtown.]

The base of the Navesink is probably at the depth of 112 feet. Its ckness combined with that of the Hornerstown doubtless exceeds 50 t.

About 1 mile south of New Egypt the Manasquan marl forms an egular area in which a number of old marl pits are located. These mostly inactive and overgrown, but at some of them marl has en dug as late as 1915. In October, 1913, Dr. Twitchell[35] ob- ved the following section at the Huggins pit:

Section at Huggins marl pit, about 1½ miles south of New Egypt.

	Feet.
Soil, gray sandy, with a few pebbles	2
Marl, olive green, apparently reworked, yellow spots and streaks	4
Marl, dark olive green to greenish black, pale-yellow specks and concretions	4
	10

Some marl was dug here in 1912–13. The surface where dug looks e fine light-gray ashes.

HORNERSTOWN.

At locality 111, about 0.75 mile southwest of Hornerstown, there a large marl pit, formerly worked on an extensive scale and con- cted with the railroad by a spur track. This pit was visited in 17 by Dr. Kümmel, from whose field notes the following observa- ns are taken:

> The old marl pit is now grown up with sizeable trees. The old switch is now torn , but the graded cut is still available. The marl is fairly well shown on the sides. the south side it lies within 1 or 2 feet of the surface and is covered with sand, h a line of pebbles at the base. If the marl extends to the bottom of the pit its ckness must be in excess of 20 feet. The excavation can be extended southward several rods and northward an equal distance without increase of thickness of er. East of the railroad is a broad field of 20 to 40 acres, or perhaps more, in which marl probably lies very near the surface. This is one of the best pits. It is now ied by the Richard Miers estate. Some marl has been dug at Hornerstown within ent years, but none has been sold.

Along Crosswicks Creek and in some of its branches the marl is posed here and there within 1 or 2 miles of Hornerstown. At

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Data on file at New Jersey Geological Survey.

locality 112, in a tributary opposite Lahaway Creek, the basa of the Navesink is exposed on both sides of the creek east o road, and characteristic fossils, including *Belemnitella*, ma found in it.

A well sunk for Charles Higgins near and southwest of the pond at Hornerstown furnishes the following record, which is both as reported and as here interpreted.

Record of well of Charles Higgins, southwest of mill pond at Hornerstown (localit

[Elevation, 20 feet (above pond?); F. R. Hope, driller.]

As reported.		As interpreted.		
		Thickness.	Depth.	Formatio
	Feet.	*Feet.*	*Feet.*	
Green marl at about	12	12	12	Quaternary(?)
		22	34	Hornerstown.
Black marl at about	34	15	49	Redbank(?).
Second stratum of iron or something tough to penetrate at	42			
Gray marl at	49	24	73	Navesink(?).
Coarse sand at	73	2	75	Mount Laurel(

As above interpreted the well shows 22 feet of Hornerstown beneath 12 feet of overburden. The base of the Navesink is pro at a depth of 73 feet. The zone between the Hornerstowı Navesink, as exposed in the ravine at locality 114, is black. conitic, and micaceous and might be called a black marl.

CREAM RIDGE AND DAVIS.

A railroad traverses the Navesink marl between Cream Ridg Davis and could supply transportation for marl or marl produc m are now inactive and more or less overgrown. From time to small amounts of marl are dug for local use.

e United States Department of Agriculture has recently arranged shipment of three carloads of greensand marl from Marlboro to nce, S. C., for experimental use on lands deficient in potash. p. 113–115.)

e following rather recent analyses of Navesink marl from the ty of Marlboro give a good idea of the phosphoric acid and h content of what may perhaps be called random or run of mine les:

Analyses of samples of Navesink marl from Marlboro and vicinity.[a]

[Collected by C. C. Engle, representing the New Jersey Geological Survey.]

Location.	P_2O_5	K_2O
	Per cent.	*Per cent.*
of Mr. Stryker, Marlboro	0.82	5.06
.do	1.20	5.44
.do	1.05	5.70
of Charles M. Wyckoff, Marlboro	1.10	6.50
.do	.94	6.28
of Joseph Holmes, Holmdel	.73	6.05
of Mr. Myers, Marlboro	1.21	4.24
of David I. Van Deveer, Marlboro	.64	5.05
of D. H. Taylor, Bradevelt	.99	4.64
.do	.39	6.16
	.907	5.512

[a] , A. W., The agricultural value of greensand marl: New Jersey Agr. Exper. Sta. Circ. 61, p. 12, 1916.

the John Van Kirk place, at Marlboro, where 10 feet of green-containing shells is overlain by 3 to 5 feet of gravel, W. C. Phalen ted a sample which was analyzed at the laboratory of the d States Geological Survey and found to contain 4.45 per cent ash.[36]

e average potash content of the Navesink marl dug near Marl- if judged by the analyses in the above table, is 1.09 per cent than the average obtained from the borings at holes 1 to 16, as bed above. (See also p. 104.) The phosphoric acid content of 1 per cent would give the marl additional agricultural value. lboro and Bradevelt are on the railroad, and the country in vicinity is sufficiently level to permit exploitation of considerable The Marlboro district is thus the most favorably situated of avesink localities for commercial development.

FREEHOLD.

Hornerstown marl comes to the surface over extensive areas vicinity of Freehold. Marl was formerly dug here but on a tensive scale than at Marlboro, and there has been little recent g. Recent analyses, showing the phosphoric acid and potash content of random or run of mine samples from Freehold, are given in the following table:

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[36] y, G. H., Notes on the greensand deposits of the United States: U. S. Geol. Survey Bull. 660,

Analyses of samples of Hornerstown marl from pit of J. W. Dobbins, Freehold.[a]

[Collected by C. C. Engle, representing the New Jersey Geological Survey.]

No.	P_2O_5.	K_2O.
	Per cent.	*Per cent.*
18	0.81	6.06
19	1.40	5.04
20	.67	5.12
Average	.96	5.40

[a] Blair, A. W., op. cit.

The average phosphoric acid content of the three samples from Freehold is slightly higher than that of the ten samples from Marlboro, but the potash content is a little lower. These differences might disappear if a larger number of analyses were available.

Freehold, because of its railroad facilities, is one of the most favorable localities in Monmouth County for the commercial development of the Hornerstown marl.

EATONTOWN.

At Eatontown and about 3 miles to the east, at Branchport, the Hornerstown marl is crossed by railroads, and at Branchport it is on tidewater at Pleasure Bay, which cuts diagonally across the marl bed. Parker Creek, a branch of Shrewsbury River, also tidewater, lies along the northwest border of the Hornerstown bed.

At locality 116, about 0.3 mile north of Eatontown, according to field notes of Dr. Kümmel, the Hornerstown marl beneath a thin cap of gravel reaches an elevation of 25 to 28 feet in the road cut at the

Analyses of samples of greensand from vicinity of Eatontown.

[Analysts, Stilwell & Gladding, New York.]

No.		Total potash (K_2O).
		Per cent.
17490	Sample from military pig pen from Monmouth Park, received from the American Potash Corporation[a] July 30, 1918	8.75
7489	Greensand "from top of knoll beside nursery," received from the American Potash Corporation July 30, 1918	8.68
9045	Greensand marked "No. 7—6½ overburden, 14 feet blue and green marl," received from the American Potash Corporation, Aug. 15, 1918. On sample dried at 212° F	8.19

[a] The Eastern Potash Corporation has taken over the rights and patents of the American Potash Corpora- n, in so far as they relate to potash extraction from greensand.

In view of the results obtained from samples already cited in other rts of the marl belt these results seem high.

A sample of fresh marl, collected at a depth of 1 foot at locality 118, the property of the Eastern Potash Corporation, was analyzed at e laboratory of the United States Geological Survey. It contained 9 per cent of potash (total K_2O), including a trace of soluble poth. This analysis, which may serve as a check upon the others, ows that the Hornerstown marl at Eatontown compares favorably th the better-grade marls elsewhere in the marl belt, but it shows o that the Eatontown material is perhaps not so conspicuously h in total potash as the analyses in the table would indicate.

According to field notes of Dr. Kümmel, the thickness of the rnerstown marl at Crawford Hill (locality 119), about 8½ miles rthwest of Eatontown is about 25 feet.

FARMINGDALE.

The Manasquan marl was formerly dug in considerable quantity in e vicinity of Farmingdale, in Monmouth County, and enjoyed a h reputation as an agricultural marl. The pit nearly half a mile rtheast of the town (locality 120), now owned by D. Mahoney, is ubtless the largest. It has long been inactive and largely filled th water. (See Pl. IX, *C*.) The following section was measured by . Kümmel[37] at the north end of the pit:

Section at D. Mahoney's marl pit, Farmingdale.

	Feet.
Pleistocene gravel	6
Laminated clay with very thin seams of sand, the laminae of sand more numerous and thicker in upper portion; the upper part of the exposure weathered to a yellow color; the lower 8 feet nearly black or very dark chocolate-colored; no glauconite. Kirkwood (Miocene)	12
Greensand marl composed of glauconite and very fine quartz sand; when wet material is plastic and coherent; only upper portion shown	2-3
	21

Kümmel, H. B., field notes on file at New Jersey Department of Conservation and Development.

The overburden at the north side of the pit is now 18 feet or mo It probably increases in that direction, but toward the northwe southwest, and south probably considerable extensions of the pit cou be made without finding much increase of overburden.

The Squankum pits, about 3 miles south of Farmingdale, whi formerly produced much marl, are now flooded.

At the pits of James H. Johnson, about three-quarters of a mi southwest of Farmingdale (locality 121), Dr. Twitchell [38] in 1912 o served the following section:

Section at marl pits of J. H. Johnson, near Farmingdale.

	Feet.
Gray sandy soil	1
Yellow sand	1
Yellow sand and abundant gravel	1
Chocolate-colored clay, laminated	2-3
Light bluish green to olive-green marl	1
	7

The marl is light greenish gray when dry, piles of it resembli piles of ashes. In 1884 N. L. Britton visited these pits and noted t following section: [39]

Britton's section at Johnson marl pits in 1884.

	Feet.
Brown sand and humus	2
Yellow drift	3
Marl	15-17
	22

The excavations are in the ash and blue marl layers of the upp marl bed.

Small thicknesses of marl are exposed along the water's edge

A sample collected by W. C. Phalen from Daniel Mahoney's property was analyzed in the laboratory of the United States Geological Survey and found to contain 3.54 per cent of potash.[40]

The thicknesses represented by these samples are unknown, but in so far as the samples are representative of the Manasquan marl they show a lower potash content than that of either the Navesink or the Hornerstown and thus confirm the similar findings at holes 17 to 19, localities 96, 97, and 100, near Pemberton. The phosphoric acid content of the Manasquan marl, as judged by these samples, is noteworthy and is probably a considerable factor in its former agricultural popularity.

The Shark River marl (Eocene) is also exposed near Farmingdale at locality 122, along Manasquan River about 1 mile below the Johnson pits, above described. In 1912 Dr. Twitchell[41] measured the following section at this place:

Geologic section on Manasquan River about 1 mile south of station at Farmingdale.

	Feet.
Yellow sand and gravel	4–6
Chocolate-colored clay, more or less weathered, with some thin sand seams at base	3–4
Marl, mottled and indurated	1+
Marl, mottled bluish green, with considerable glauconite and drab clay specks and streaks	6
Water's edge.	
	17

The marl is fossiliferous close to and in the indurated portion. A similar exposure with less marl occurs at locality 123, about 0.1 mile farther up the river.

POPLAR AND ELBERON.

Along the creek about 0.75 mile south of Poplar, in Monmouth County, the old marl pits at locality 124 and vicinity are much overgrown, but on the north side of the creek the upper part of the Manasquan marl is exposed with the base of the Kirkwood. Dr. Kümmel visited this locality in 1917 but found no fresh openings.

At locality 125, about 0.8 mile southwest of the station at Elberon, in Monmouth County, Dr. Twitchell found, in 1912, an exposure of Shark River marl in a gully near the barn of the Deal Golf and Country Club. Beneath 4 feet of yellow sand and gravel he found 3 feet of fairly uniform mottled grayish-green marl with clay specks. There were old marl pits in the vicinity.

The main body of Shark River marl lies about 0.6 mile south of Elberon and occupies an area about 1½ miles long at the coast and

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[40] Ashley, G. H., op. cit., pp. 39, 47.

[41] Twitchell, M. W., field notes on file at New Jersey Department of Conservation and Development.

stretches back 1 to 2 miles from the shore. This area is now l
a residential district with pleasure grounds.

Two wells drilled at South Elberon near the railroad and
half a mile north of the Deal Beach station furnish the following
bined record, which is slightly modified from Kümmel's accoun

Combined record of two wells at South Elberon (locality 126).

	Thickness.	Depth.	Formatic
	Feet.	*Feet.*	
Sand and gravel	12	12	Cape May cene).
Greensand marl	78	90	Manasquan.
Quartz sand with some marl grains	40	130	Vincentown.
Quartz and lime sand with some limerock and numerous shells	70	200	Do.
Greensand marl	100	300	(Hornerstown
Red sand, becoming black sand at base	59	359	Redbank (?).
Clay	19	378	Navesink (?).
Sand	31	409	Wenonah (?).
Clay	35	444	Marshalltown
Sand	21	465	(Englishtown
More clayey sand	7	472	Do.
Sand	33	505	Do.

The Manasquan marl is unusually thick (78 feet) and h
overburden of 12 feet. The lime sand also is well develope
deeply buried. The top of the Hornerstown lies at a depth
feet and is 100 feet thick. There is some uncertainty abou
correlation of the beds in the lower part of the section.

ASBURY PARK.

The records of several wells at Asbury Park have been st
by Woolman [43] and compiled into a single record, which, in si
form, is presented below:

Here the Hornerstown marl is 40 feet thick and lies 240 feet below he surface. The Navesink marl is reported as 93 feet thick. The incentown contains only a thin layer of lime sand. The greensand ember of the Manasquan is 20 feet thick, though the formation as a hole is 100 feet thick.

OCEAN GROVE.

A well at Ocean Grove shows the marl beds at somewhat greater epths and with more variations in thickness. The following record simplified from that of Woolman.[44]

Record of well at Ocean Grove.

[Elevation, 20 feet. Uriah White, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
rface sands	20	20	Recent.
ownish clay, called rotten stone	55	75	[Kirkwood?]
ght-colored clay, resembling "ash marl" below	30	105	[Shark River?]
re greensand	8	113	
itish clay with coccoliths and Foraminifera, the "ash marl" of Prof. Cook.	47	160	[Manasquan.]
rker clay, much mixed with greensand; greensand layer t 172 to 193 feet.	48	208	
rd clay with greensand grains through it	19	227	
y with much greensand, Bryozoa, echinoid spines, Foraminifera at 261 to 264 feet.	37	264	[Vincentown.]
ayish greensand, with Foraminifera	20	284	[Hornerstown.]
eensand with comminuted shell at bottom	16	300	Redbank.
eensand; shell at 362 feet	81	381	[Navesink.]
ay sand; comminuted shell	76	457	[Mount Laurel and Wenonah.]
her strata; water from layer at bottom	677	1,134	

Here the top of the Hornerstown is at a depth of 264 feet. The lornerstown and Navesink together represent a thickness of 101 eet but are separated by a greensand layer, presumably less glaucoitic, 16 feet thick.

SEA GIRT.

The New Jersey coast cuts obliquely across the strike of the Coastal lain strata in this part of the State, so that a well at Sea Girt, which s 6 or 7 miles nearly south of Asbury Park, strikes the marl beds arther down their dip than wells at either Asbury Park or Ocean rove. A well at the Beach House furnishes the following record, hich is simplified from Woolman's account.[45]

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[44] Woolman, Lewis, op. cit., p. 74.

[45] Idem, p. 76.

Record of well at Beach House, Sea Girt.

[Elevation, 11 feet. Uriah White, driller.]

	Thickness.	Depth.	Formation.
	Feet.	*Feet.*	
Beach or dune sand	10	10	Recent.
Yellowish clay	2	12	
Yellow sand and gravel	13	25	
Solid blue sandy clay	25	50	Post-Pliocene or cene.
Solid blue clay, with streaks of sand and wood	10	60	
Fine white sand	6	66	
Hard rock	4	70	
Sand and shell	9	79	
White sand	47	126	
Brownish clay, with streaks of sand; lignite at 126 to 146 feet	109	235	[Kirkwood.]
Light-colored greenish clay much like ash marl below	25	260	[Shark River?]
Black sand marl, glauconitic; blue marl of Cook	15	275	
Light-green marl, contains Foraminifera at 285 to 306 feet; hard blue stones; ash marl of Cook.	70	345	[Manasquan.]
Black sand marl, glauconitic; green marl of Cook	15	360	
Light greenish-gray clays	40	400	
Gray marl; equivalent to lime sand	50	450	[Vincentown?]
Black marl; equivalent to middle marl bed and red sand	39	489	[Hornerstown and bank?]
Sandy marl	81	570	[Navesink.]
Sand, water bearing	50	620	[Mount Laurel Wenonah.]
Other strata	135	755	

Here the top of the Hornerstown is apparently 450 feet below surface.

LAKEWOOD.

From specimens and information regarding two wells at Lakew Woolman [46] compiled a record which is presented below in simp form.

Record of two wells at Lakewood.

[Elevation, 50 feet; depths, 475 and 612 feet. Uriah White, driller.]

Depth of

ıd referred above to the Manasquan, which here seems unduly .ould be ascribed to the Vincentown. The top of the Hornershere at a depth of 370 feet.

ATLANTIC CITY.

p well at Atlantic City shows the depth of the marl beds at ɘrnmost limit of the Coastal Plain, at a point about 45 miles ɜ outcrop in the direction of the dip. The well was drilled 000 feet out on Young's ocean pier at the foot of Tennessee The record as compiled by Woolman [47] is presented below ɜr form.

Record of well at Young's Pier, Atlantic City.

[Elevation of pier, 20 feet. Uriah White, driller.]

	Thickness.	Depth.	Age or formation.
	Feet.	*Feet.*	
to mean tide level	20	20	
vel to bottom of water)	(15)	35	
etc.	237	272	Post-Miocene.
diatom beds, gravel, greensand, etc., including ɜet the Atlantic City 800-foot water horizon.	943±	1,215	Tentatively Miocene.
arl	25	1,240	[Shark River?]
ɔugh light and dark slate or ash-colored clays iths and Foraminifera.	200	1,440	[Probably Manasquan.]
careous rock, soft or hard; two-thirds consists ɘqual mixture of greensand and quartz; the is carbonate of lime, the cementing material; raminifera.	460	1,900	[Probably Vincentown.]
reensand marl	40	1,940	[Probably Hornerstown and Navesink.]
rith a little greensand	70	2,010	
ı-colored clay, "hard almost as rock"	60	2,070	
reensand marl similar to that at 1,900 to 1,940	80	2,150	
: micaceous sandy clays	156	2,306	[Mount Laurel and Wenonah?]

ıp of the Hornerstown marl is here apparently at a depth of t. Two beds of greensand, 40 and 80 feet thick, are sepa- 130 feet of clay. The thickness of the overlying Vincentown) feet, is the maximum recorded thickness for that formation, . not, however, so calcareous here as in Salem and Burlingties.

SUMMARY OF FIELD DATA AND ESTIMATES.

vell three greensand beds of commercial quality and thickɘ been recognized, which with some variations are generally ɜhable throughout the region where borings were made. ɘ gray or bank marl, green marl, and chocolate marl. The table gives the range in thickness and quality of these ls at the five localities explored.

, Lewis, New Jersey Geol. Survey Ann. Rept. for 1901, pp. 110-114, 1902.

Thickness and potash content of commercial beds of greensand at five localities Gloucester, Camden, and Burlington counties.

Locality.	Gray marl.		Green marl.		Choco
	Thickness.	K_2O.	Thickness.	K_2O.	Thick-ness.
	Ft. in.	*Per cent.*	*Ft. in.*	*Per cent.*	*Ft.*
Salem	12 4	6.19	9	7.19	[a] 2
Woodstown	12	6.12	11 7	7.58	8
Sewell	8 4	6.09	10 10	7.52	15
Somerdale	....	....	9 1	7.35	18
Elmwood Road	9 7	6.01	12 11	7.26	28
	10 7	[b] 6.11	10 8	[b] 7.39	14

[a] Not characteristic chocolate marl; may belong with overlying bed.
[b] Average weighted according to the thicknesses of the beds at their respective localities.

The middle bed or green marl is distinctly richer in pota the other beds, but probably all contain sufficient potasl considered workable by any process that could utilize the rich

The following table gives a summary for the five districts ated of the data regarding the thickness of the marl as a wh of the amount and value of the contained potash:

Summary of thickness of the Hornerstown and Navesink marls and of estimates and value of the contained potash for five districts ranging northeastward fr County, into Burlington County.

District.	1	2	3	4	5	6	7	
	Number of holes (in cludes	Average thick-	Number of Survey	Average thickness at	Average content	Estimated content of potash per	Value of potash per ton of greensand.[a]	Value per gr

te marl as determined at holes 8 to 10. The resulting average es very well with the averages for the adjacent districts.

lumn 2 the final average is weighted according to the number and the average thickness at the respective localities.

lumn 3 only Survey borings which entered the Hornerstown vesink marls are included.

lumn 4 the final average is weighted according to the number and the average thickness at the respective localities.

lumns 5 and 6 the final averages are weighted according to rage thickness and potash content of the marl at the respecalities.

lumn 7 the final averages are not weighted.

lumn 8 the final averages are weighted according to the estitonnage per acre at the respective localities.

e region from Medford to Birmingham and Pemberton seven hich show an average thickness of about 45 feet for the comIornerstown and Navesink marls, indicate the northeastward ation of the marl in commercial thickness beyond the region d by Survey borings.

bstown 56 feet of marl probably referable to the Hornerstown vesink is reported. The records of three wells at Wrightsnd New Egypt show great thicknesses of marl, parts of which bably referable to the Manasquan or Vincentown. They , however, the northeastward continuation of a great body Navesink and Hornerstown marls.

heast of Sykesville the two beds are separated by the Redbank At Hornerstown a well penetrated 22 feet of green marl and of gray marl, probably assignable respectively to the Hornersnd Navesink. Between these beds lies 15 feet of more or arly material thought to represent the Redbank. Near own and at Crawford Hill (locality 119) measurements by mmel indicate a thickness of 20 to 25 feet of Hornerstown Thus it appears that in the region where the Hornerstown vesink marls are distinct they tend to maintain thicknesses if combined would equal or exceed their combined thickness est of Sykesville. Each of these beds is present in commercial in Monmouth County hand for localities where it is accessible suggest that the more glauconitic portions of the marl are thinner and contain from 2 to 4 per cent less potash than the averages for the combined Navesink and Hornerstown given in the above table. It is thus probably unsuited for the commercial extraction of potash, but there is no apparent reason why it might not again find favor for direct application as a fertilizer to soils deficient in potash or phosphoric acid.

GENERAL ESTIMATES FOR ENTIRE MARL BELT.

Washington[48] estimates that the greensand beds in New Jersey contain 2,034,000,000 metric tons, equivalent to about 2,243,114,000 short tons of potash. This estimate is based on the assumption of a bed of greensand 6 meters (about 20 feet) thick, containing 6 per cent of potash (K_2O), and occupying a belt 160 kilometers (99.4 miles) long and 16 kilometers (9.9 miles) wide. These assumptions appear to be fully justified, except, perhaps, that for the width of the belt. The marl doubtless underlies all that portion of the State southeast of the line of its outcrop and contains potash throughout its breadth, a much wider area than the 16-kilometer strip. Most of the deposit, however, is inaccessible because of the overburden, which, on account of the geologic structure, increases toward the southeast. In Monmouth County, as previously shown, the part of the marl accessible by open-pit mining occupies an area 10 miles or more wide, though much of this area is also underlain by the Redbank sand. Farther southwest the similarly accessible portion of the belt is much narrower.

In Monmouth County the Navesink and Hornerstown marls are distinct, but for purposes of computation they may be considered

ed. Wells southeast of the marl belt and along the shore
e a thickening of the greensand belts in the direction of the
There are, however, no data about the maintenance or change
lity in that direction. The maximum recorded depth of the
the Hornerstown appears to be 1,900 feet in the well at
ic City.

SUMMARY FOR LIME SAND.

lime sand in probable commercial thickness is exposed or has
ecognized in wells as far north as Wrightstown. Northeast-
'rom this place the Vincentown sand becomes predominantly
ose. The lime sand is reported as 25 feet thick in Salem
7, but at the well of the Salem Water Co., at Quinton, it is 108
ick, and at Atlantic City 460 feet thick. In the well of William
k, near Vincentown, it is 31 feet thick, and at Woodstown it is
, or more thick. The maximum reported content of carbonate
e is 84.7 per cent in a sample from Mannington Township,
County, but the average of three samples from that township
nly 66 per cent; 80 per cent material is reported from locality 61,
f Clementon, Camden County. No systematic measurements
iples of the lime sand are available. Ordinarily it has con-
)le overburden and lies a mile or more from available sites
ensand exploitation.

COMMERCIAL DEVELOPMENT.

iough small amounts of potash have been manufactured from
Jersey greensand and marketed, there has been as yet no
cale commercial operation or production. In 1916 the
ly Chemical Co., of Camden, N. J., under the direction of

above New York City. The plant was designed to produce 1 ton of potash a day but was only experimental and not intended for commercial production. The process as at present developed is described below in the account of the Eastern Potash Corporation. In 1917 the company, having changed its name to the American Potash Corporation, continued experimental operations at Jones Point[a] and claimed to have solved the difficulties of extracting potash on a commercial scale from the greensand of New Jersey. Among the proposed by-products were "agricultural lime," brick, tile, and artificial stone. No production of potash was reported by the company during the year.

The Eastern Potash Corporation was subsequently organized to take over the rights and property of the American Potash Corporation in so far as they related to the production of potash and by-products from greensand. This corporation, with offices in New York, continued the experimental work at the Jones Point plant and produced and marketed in 1918 a small quantity of high-grade caustic potash. The company now has under construction near New Brunswick, N. J., a plant designed to treat 1,000 tons of greensand per day. According to a recently published statement[a] the process which this company claims to have demonstrated commercially consists in grinding the greensand in ball mills to 200 mesh, and then digesting the material with milk of lime in an autoclave or a special type of continuous digestor for 30 to 60 minutes with steam at a pressure of 200 pounds. The lime (CaO) should equal the weight of the greensand. The digested material is filtered twice, and a solution containing about 80 per cent of the potash in the charge is evaporated in a multiple-type evaporator from an

N. J. (see Pls. II and VIII, *A*), and has marketed a small quantity of high-grade potash extracted therefrom in its experimental plant at Stockertown, Pa. The process consists in preheating the greensand to 350° C., mixing it with calcium chloride, passing the mixture through a furnace at about 850° C., leaching the product, and finally obtaining potassium chloride by evaporation and crystallization. The company had suspended operations by the fall of 1918 but was planning to erect a plant on its ground near Marlton. No further progress has been reported to the Survey.

The large-scale experiments of F. Tschirner at Yorktown [54] in 1917 led to the establishment of the R. S. Ryan Co.'s plant at Reeves station (Pl. IX, *D*), 2 miles north of Medford, in Burlington County, where the company had acquired ground. The plant, which is regarded as only for commercial experiment, handles about 50 tons of greensand and produces from 2 to 3 tons of potassium chloride (KCl) per day. The process consists in grinding greensand and lime sand, taken from the company's pits near the plant, mixing these with salt, and heating the mixture in a rotary kiln. The clinker is leached in water, and the potassium and sodium chlorides are removed by evaporation and crystallization. Most of the sodium chloride is recovered and used over again. Potassium chloride, running 88 to 90 per cent, with a little potassium sulphate, is produced. By March, 1919, the company had sufficiently overcome initial difficulties to start commercial operation. In September of the same year the plant was reported closed. The figures for production are not available.

In the fall of 1918 the newly organized Reduction & Concentration Corporation acquired a factory building and grounds at Gloucester, N. J., for rendering soluble the potash in greensand and making complete fertilizer in which was to be incorporated the treated greensand. Preliminary arrangements were made for utilizing greensand from properties of the Norcross & Edmunds Co. at Birmingham and of the West Jersey Marl & Transportation Co. at Sewell. Installation of machinery and experimental work were said to be in progress from January to March, 1919, when the writer was in the vicinity, but no information as to the process was divulged, and no opportunity was afforded to view the operations. No production and no further activity of the corporation have been reported to the Survey.

In 1918 the Coplay Cement Manufacturing Co., of Coplay, Pa., which had recently installed a Cottrell dust-collecting system and equipment for the extraction of potash from flue dusts, experimented with greensand from Birmingham, N. J., as a constituent of its cement mixture to see if the amount of potash recoverable from these dusts could be increased. The company's usual mixture tained about 1 per cent of potash. The greensand employed tained about 7 per cent of potash, so that its use in the propor selected for the experiments would nearly double the amou potash available for volatilization. The experiments showed the potash was largely volatilized, and that the cement, th darker colored on account of the iron in the greensand, was sa under the market conditions then existing. The company acquired greensand deposits near Kirkwood, in Camden Co (locality 60, Pl. II), and began commercial utilization of the g sand. After a few runs, but not from any difficulty arising the use of greensand, it became necessary to shut down the collecting units of the plant. These were still inactive in Oct 1919, but resumption of activity was expected if the potash m seemed favorable.

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[54] Gale, H. S., and Hicks, W. B., op. cit.

A number of other processes for the extraction of potash greensand have been devised and most of them patented. of these processes, however, has reached so advanced a sta large-scale experimentation as those above described.[55]

OUTLOOK.

The development of a potash industry based on the New J greensands depends on the ability of the manufacturers to com not only with foreign producers but also with American produce

According to Hicks [56] the prices of German potash salts deli before the war under special contracts for large quantities direct the source of production to Gulf and Atlantic ports were as follow

Wholesale prices per short ton of potash salts c. i. f. Atlantic ports, 1911–191

As will be observed from the table, net prices to large importers varied from 57 cents per unit (20 pounds of K_2O) for the lowest-grade product to 83 cents for sulphate. The list prices, which are generally shown in market quotations in the United States, correspond to 67 cents per unit for the low-grade material and 98 cents for sulphate. Ocean freight rates to the United States on these salts in bulk from Hamburg averaged about $2 per metric ton to northern ports and $2.50 to $2.90 to southern ports.

After the embargo of January 30, 1915, placed on the exportation of potash salts from Germany, the prices of these salts rose rapidly. Early in 1915, market quotations on 80 per cent muriate were around $115 a ton and gradually rose to $500 a ton in December. The quotations in 1916 varied from $300 to $490 a ton, in 1917 from $325 to $450 a ton, and in 1918 from $260 to $350 a ton. These quotations are not indicative of the actual selling price of potash materials, as only limited quantities of muriate were on the market and muriate was at a premium because of its use as a raw material in the manufacture of various refined potassium salts. The actual selling price in the eastern markets of the domestic output was about $4.87 per unit in 1916, $4.79 in 1917, and $4.61 in 1918. These data are shown in the following table.

Wholesale price of potash in the United States, 1915–1918.

Year.	Market quotations of 80 per cent muriate.[a]						Approximate average selling price per unit of K_2O of domestic output.	
	Per short ton of salt.			Per unit of K_2O.			F. o. b. plant.	Eastern markets.
	High.	Low.	Average.	High.	Low.	Average.		
1915	$500	$115	$245	$10.00	$2.30	$5.90	$3.14	$3.64
1916	490	300	415	9.80	6.00	8.30	4.37	4.87
1917	450	325	380	9.00	6.50	7.60	4.29	4.79
1918	350	260	315	7.00	5.20	6.30	4.11	4.61

[a] Quotations for 1915 and 1916 taken from Jour. Ind. and Eng. Chemistry and for 1917 and 1918 from Oil, Paint, and Drug Reporter.

When the armistice was signed in November, 1918, only a few large producers in the United States had made their original investments out of the potash industry, many plants had been operated only a short time, and others were under construction. About one-third of the potash produced in 1918 was still in the hands of producers, money for operating expenses had been advanced on the potash held in storage, and developments had gone forward under the prevailing price of $4 to $5 per unit of potash. Anticipation that low-priced potash from foreign sources would be available followed the armistice agreement, checked sales of domestic potash, and caused the price to fall to about $2.50 per unit—a price lower than the cost of production of many producers. These conditions caused a crisis in the potash industry, and producers began to close their plants. By the early part of 1919 nearly all producers had shut down and some had gone out of business.

The cost of production of American salts is summarized by Gale and Hicks[57] as follows:

Available data on the cost of producing potash from the various American sources are very meager, but if the following estimates of cost production are correct they indicate that undoubtedly some of the large developments will survive. Condra gives the cost of producing potash in the alkali-lake region of Nebraska as between $20 and $44 a short ton, or an average of $30 a short ton of crude salts. This corresponds to an average of about $120 a ton of potash ($K_2O$). The conditions as regards labor, fuel, and supplies in this region are very difficult, and the cost should be considerably reduced if such conditions are improved. It has been stated that sulphate of potash can be produced from alunite at Marysvale, Utah, at approximately $20 a ton (equivalent to about $40 a ton of K_2O), and that if an aerial tramway were installed the cost would be reduced 50 per cent. Porter estimates that the present cost of production, exclusive of royalty, depreciation, and similar items, by the Security Cement & Lime Co., Hagerstown, Md., is about $30 a ton of pure potash (K_2O) packed on board cars, and that under normal conditions the price might be reduced 50 per cent. Treanor, from his experiences as manager of the Riverside Portland Cement Co., thinks the cost of saving potash from flue dust may run $100 a ton of K_2O for the first month, may average $40 a ton of K_2O the first year, and that it may ultimately be reduced to less than $20 a ton of K_2O.

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[57] Op. cit., p. 403.

Estimates of the cost of American production thus run from $20 to $120 a ton of K_2O or from $0.20 to $1.20 per unit.

Wells[58] in describing the plant of the Eastern Potash Corporation estimates that the cost of producing caustic potash in a plant with a capacity of 1,000 tons of greensand per day, including interest and general plant depreciation, may reasonably be as much as $1.50 per unit of K_2O. Such a plant would produce about 45 to 50 tons of K_2O as caustic potash and would turn out about 2,000,000 brick per day. It should, however, be borne in mind that the cost of raw material for the brick is greater than that for ordinary brick and that the by-product brick, to find a suitable market, must possess some special attractiveness such as color, endurance, or adaptability to particular uses. With the requirement of a specialized market the disposal of so much brick might prove a problem in itself.

It is doubtful if companies making potash their only product in the treatment of greensand can do so for less than the $1.50 per f German potash will hereafter greatly exceed and perhaps be as uch as double pre-war prices. On the other hand, there is the ossibility that in the United States the cost of labor and fuel may ave reached its peak and that with the resumption of industries terrupted by the war and with increased production these costs ay decline.

The American potash industry thus bids fair to be on a nearly ven basis with foreign potash industries. Whether or not greenand may have a place in the American potash industry will depend n how well the greensand operators may be able to compete with estern producers.

AVAILABILITY OF POTASH IN GREENSAND.

The scarcity of potash and the high prices of fertilizers during he war led many farmers to think again of greensand as a source of rtilizer. Although accounts of its use in the early reports were ighly favorable, the results of more recent local applications were ontradictory, and the writer received many inquiries about the vailability of the potash in greensand.

From the standpoint of the fertilizer manufacturer the potash is ot considered available because of its slight solubility in water. ecent experiments conducted by True and Geise, of the Bureau of lant Industry, United States Department of Agriculture, show hat plants in their early growing stages will assimilate potash from reensand as effectively as from the usual soluble commercial potassium alts. These authors[60] used two sets of carefully controlled pot cultures of wheat and red clover with nutrient solutions. In one set the otash was supplied by the usual commercial salts; in the other set otash was supplied by greensand in proportions such as those ormerly employed in agricultural practice, all other sources of otash being excluded. They reached the following conclusions:

> It has been shown by pot experiments carried out with crushed quartz and Shive's ulture solution as a basis that greensands and greensand marls from Virginia and New ersey are able to supply sufficient potassium to satisfy the demand of Turkey Red heat and red clover during the first two months of their growth. This enables them o make a greater dry weight of tops than was seen in similar cultures in which the otassium demand was supplied by potassium chlorid, potassium sulphate, and otassium phosphate. The prompt availability of sufficient potassium to meet the eeds of many, perhaps most, farm crops seems to be indicated.

It is reported that the New Jersey Agricultural Experiment Station as been working on the same problem and has reached similar onclusions.

In a letter to the Director of the United States Geological Survey Dr. True points out that land which already has a sufficient supply of potash and the other ingredients supplied by greensand marl not be benefited by application of it. This may account in s measure for the contradictory nature of the reported results o use. Dr. True further states that arrangements have been n for the shipment of three carloads of greensand from deposits Marlboro, N. J., to the vicinity of Florence, S. C., where it is t applied to fields known to be deficient in potash. Results of int and value are to be expected from these experiments.

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[60] True, R. H., and Geise, F. W., Experiments on the value of greensand as a source of potassium for lant culture: Jour. Agr. Research, vol. 15, pp. 483-492, Dec 2, 1918.

More recent experiments along a somewhat different line l been carried out by McCall and Smith, of the Maryland Agricult Experiment Station. These authors[61] composted greensand sulphur, soil, and manure in varying proportions, taking sam from time to time, extracting these samples with distilled water, analyzing the water extracts for their acidity and their sulp and potassium content. Two types of greensand were used, from Sewell, N. J., containing 5.88 per cent of potassium (K), the other from Crownsville, Md., containing 1.42 per cent of p sium. Each compost had as a basis 1,500 grams of greens 500 grams of commercial flowers of sulphur, and 0, 250, or 500 gr of partly rotted yard manure, aid-dried and ground fine. In s of the tests Collington sandy loam and precipitated calcium carbo were used, also small percentages of the sulphates of iron and alum The following results were obtained:

1. In composts consisting of greensand, manure, and soil in different propo an appreciable amount of the potassium was made water-soluble through sul cation.

2. The composts containing the largest proportion of manure developed the hi degree of acidity, oxidized the greatest amount of sulphur, and produced the la

9. In the composts containing manure the total amount of potassium recovered in e water extracts varied from 9.1 per cent to a maximum of 4[illegible] per cent of the total amount present.

10. Our results indicate that the composting of greensand [illegible] with sulphur and manure may prove to be a practical and efficient method for obtaining available potassium from comparatively insoluble materials.

In the opinion of the writer part of the benefit derived from the e of marl may be the result of an improved texture produced by e mechanical mixture of the greensand with the soil. For example, mass of clayey greensand applied and worked into a light sandy soil ould produce a more loamy texture besides furnishing potash. On e other hand, similar greensand applied to a stiff clayey soil would nd to emphasize the heaviness of such a soil and might be injurious.

EARLIER VIEWS ON AGRICULTURAL VALUE.

Little was known in the earlier days about potash in greensand marl and its part in the beneficial action of the marl upon crops. On the other hand, the importance of the phosphoric acid and lime as beneficial constituents was strongly urged. For those interested in reverting to the use of marl as a fertilizer it may be well to repeat the conclusions drawn years ago by Cook:[62]

1. That the most valuable marls and those which will best pay the cost of long transportation are those which contain the largest percentage of phosphoric acid.

2. That the most durable marls are those containing carbonate of lime, the more the better.

3. That greensands containing but little of either phosphoric acid or carbonate of lime become active fertilizers when composted with quicklime.

4. That marls which are acid and burning from containing sulphate of iron can be rendered mild in properties and useful as fertilizers by composting with lime.

5. That crops particularly improved by it are all forage crops, grass, clover, etc.; for these the green marl may be spread upon the surface to the amount of from 100 to 400 bushels per acre. The crop is generally doubled and in some cases quadrupled by this application. Other marls must be used in larger quantities, but will produce good results.

Potatoes: For this crop marl seems to be a specific. It does not materially increase the growth of the vines, and the yield is not much greater, but the potatoes are smoother and fairer in the skin and dryer and of better quality when boiled. The marl is put on the potatoes in the hill at planting; if not acid, it is thrown directly on the tuber; if acid, the potato is first covered by earth and the marl thrown on or beside that. From 5 to 30 tons may be used on an acre.

Buckwheat: Most remarkable effects upon this crop are produced by marl. Two and one-half tons, or 50 bushels to the acre, spread on after sowing, have caused an equal amount of buckwheat to grow on land which otherwise was not worth cultivating.

Wheat, rye, oats, and corn are improved by the use of marl, though not with the striking results seen on the crops before mentioned. It is applied as a top dressing on the prepared ground, is spread on the surface before plowing, is worked in the hill or drill, or is composted with barnyard manure and spread on the ground according

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[62] Cook, G. H., Geology of New Jersey, pp. 452-453, 1868.

In the course of drilling variations were observed in t
the marl and in the relative proportions of the different
Quartz was present in all the samples in greater or less
served as an adulterant, lowering the potash content.
constituents, however, consisted in part at least, of fi
glauconitic material, so that their presence might or mig
a reduced potash content. In order to study the differ
ents of the marl and their relative proportions in the p
of commercial thickness mechanical analyses were unde
what along the lines of the work of Cook [63] and Ashley.[64]
ing investigations were carried out: (1) Wet separation
the relative proportions of coarser and finer constituen
netic separation of coarser residues to determine the p
magnetic materials, chiefly glauconite; (3) sizing the pr
magnetic separation to determine the sizes and shapes o
grains and the relative abundance of grains of certa
shapes; (4) microscopic study of glauconite grains in
(for discussion see pp. 139–140); (5) chemical analyses o
products of the wet and magnetic separations (discussed

PREPARATION OF SAMPLES.

Composite samples, 15 in all, derived from 87 origina
pared to represent each bed of commercial thickness at
six localities explored. Each sample weighed approx
grams and was made up of weighed portions of all sa
from the given bed at the given locality, each in propo
thickness represented by it. The material was weig
preliminary drying, but at the end check samples weighi
were dried under the same conditions to which the compo
were subjected and reweighed to determine the loss of

eated and continued for an hour and three-quarters. At material released by washing was of a brownish color and ly heavy, settling in a comparatively few minutes. This ared after five or six washings, however, and a light yellowish aterial was developed, which clouded the solution and ap- without evident diminution at every washing. Compara- ittle of this cloudy matter had settled, even after standing ght. A few drops of dialyzed iron, added to the solution at gestion of George Steiger, caused the flocculation and pre- on of the fine suspended matter and the clearing of the l.

cond preliminary trial was made to determine whether the material above mentioned was present as detached particles original sample or whether it was developed from the green- ains by agitation in washing. About 25 grams of greensand h claylike material was relatively abundant, was placed in a on a stand under a faucet. The inflow of water was directed nnel to the bottom of the beaker. The "clay" was soon out and the solution cleared. Some cloudiness of the water veloped, however, when the greensand was agitated with a d. This was done at intervals of a few minutes for a period ly four hours, and the cloudiness appeared at each agitation. ar water was then poured off except about 50 cubic centi- in which the greensand was again stirred briskly with a rod. udiness at once reappeared just as abundantly as at the ages of the washing.

as concluded that the glauconite grains were yielding fine s either by mechanical wear of grain on grain or by the flow r over the grains. Of the two agencies the former is appar- he more effective, because practically no cloudiness appeared the constant flow of water through the beaker. The test s that much of the "clay" that is so abundant in some beds nsand is really composed of finely comminuted glauconite Its presence in the marl, therefore, does not necessarily imply quality.

aking the separations tabulated below the following proce- as observed. After placing the weighed sample in a beaker at more than enough distilled water to cover it was added. ensand was then stirred vigorously with a rod for one minute owed to settle for 30 seconds, after which the cloudy liquid canted to a second beaker. These operations were repeated tal of 10 times for the first five samples and 15 times for the ng 10 samples. The washed greensand was then removed sserole, dried on a steam bath, and weighed. A few drops yzed iron were added to the cloudy liquid, which was then l to settle, after which the clear water was decanted and the settlings dried and weighed in the same manner. In samples G-10, G-13, G-14, and G-15 the entire washing waters were d without flocculation and precipitation by dialyzed iron.

Wet separations of composite samples of greensand from Survey borings.

Locality.	Sample No.	Approximate thickness of bed.	Weight of sample.	Residue from washing.		Material washed out.		Lo weig was a dry
				Grams.	Per cent (A).	Grams.	Per cent (B).	
		Feet.	*Grams.*					*Gr*
Salem	G-1	12	100	93.44	95.6	4.25	4.5	
	G-2	11	100	95.07	97.3	2.62	2.7	
Woodstown	G-3	11	100	77.04	79.3	20.07	20.7	
	G-4	11	100	84.73	85.7	14.17	14.3	
	G-5	7	100	86.65	88.8	10.95	11.2	
Sewell	G-6	8	100	51.59	53.4	45.09	46.6	
	G-7	12	100	79.75	81.5	18.05	18.5	
	G-8	13	100	84.34	86.2	13.50	13.9	
Somerdale	G-9	8	100.1	39.47	40.0	59.19	60.0	
	G-10	6	100.12	50.94	52.4	46.20	47.6	
	G-11	14	100.04	69.42	71.2	28.07	28.8	
Elmwood Road	G-12	4	100.04	86.70	88.3	11.49	11.8	
	G-13	18	100.04	94.39	97.3	2.62	2.7	
	G-14	23	100.07	81.52	84.3	15.19	15.6	
Pemberton	G-15	9	100.07	75.24	76.8	22.70	23.2	
Average					[a] 80.5		[a] 19.5	

[a] Average weighted according to the thicknesses of the respective beds.

For the check tests on loss of weight in washing and drying samples were selected, weighed, dried over night on the steam b and reweighed with the following results:

Moisture determinations on samples of greensand.

Locality.	Field No. of sample.[a]	Original weight.	Weight at about 100° C.	Lo wei
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

t the poles of a powerful electromagnet. The glauconite was ted and held to the glass plate so long as the plate was in it with the poles of the magnet. By lowering the plate the nite could be dropped into any convenient receptacle. This was repeated until no further results were shown, and thus complete separations were obtained.

tabulated below the numbers of the samples and the beds ented are the same as for the wet separations. Ten-gram poris of each sample were used, and the products of the separations veighed.

Magnetic separation of samples of washed greensand.

cality.	Sample No.	Weight.	Magnetic portion, chiefly glauconite.		Nonmagnetic portion, chiefly quartz.		Excess or loss after separation.	Glauconite grains in original sample (C×A, p. 118).
			Grams.	Per cent (C).	Grams.	Per cent (D).		
		Grams.					*Gram.*	*Per cent.*
....	G-1A...	10	8.87	87.3	1.29	12.7	+0.16	83.5
	G-2A...	10	9.45	94.1	.59	5.9	+ .04	91.6
	G-3A...	10	8.09	80.4	1.97	19.6	+ .06	63.8
wn........	G-4A...	10	9.60	96.0	.39	3.9	- .01	82.2
	G-5A...	10	9.30	92.5	.75	7.5	+ .05	82.1
	G-6A...	10	8.27	82.3	1.78	17.7	+ .05	43.9
....	G-7A...	10	9.77	97.0	.30	3.0	+ .07	79.1
	G-8A...	10	9.51	94.5	.55	5.5	+ .06	81.5
	G-9A...	10	9.32	92.6	.74	7.4	+ .06	37.0
le........	G-10A..	10	9.70	96.6	.34	3.4	+ .04	50.6
	G-11A..	10	9.62	96.0	.40	4.0	+ .02	68.4
d Road......	G-12A..	10	6.24	62.5	3.75	37.5	— .01	55.2
	G-13A..	10	9.50	94.5	.55	5.5	+ .05	91.9
	G-14A..	10	9.65	96.0	.40	4.0	+ .05	80.9
on........	G-15A..	10	5.27	52.4	4.79	47.6	+ .06	40.2
erage a......	....	....	....	89.9	....	11.1	....	73.1

ages weighted according to thicknesses of beds represented.

e excess after weighing was probably due in part to the moisture from the humid air by the dried greensand during the operaof separation and weighing. The percentage of magnetic rials, chiefly glauconite, in the washed greensand is generally being more than 90 in 10 of the 15 samples and averaging 89.9 ll the beds represented. The percentage of glauconite grains e unmodified greensand is shown for each bed at each locality e last column of the table. The final average shows 73 per cent uconite for the entire thickness of the greensand examined at of the six localities. This figure does not include the finely ed glauconitic material occurring in the greensand as mud or r" (B in the table on p. 118). No mechanical separation of this was attempted, but the chemical analyses on page 125 indicate it is probably highly glauconitic.

SIZE OF GRAINS.

th products of the magnetic separation (C and D of the table) passed successively through a series of sieves having 20, 40, 60, *Size of grains of glauconite, quartz, etc., in washed greensand*—Continued.

Locality.	Sample No.	Glauconite, etc. (C).				Quartz, etc. (D).			
		Quantity in sample (grams).	Quantity held on sieves.			Quantity in sample (grams).	Quantity held on sieves.		
			Mesh.	Grams.	Per cent.		Mesh.	Grams.	Per cent.
ll	G-8A	9.51	20	0.25	2.6	0.55	20	0.14	24.1
			40	4.72	49.6		40	.24	41.4
			60	3.14	32.9		60	.14	24.1
			80	.71	7.5		80	.02	3.4
			100	.47	4.9		100	.02	3.4
			100+	.23	2.4		100+	.02	3.4
				9.52	99.9			.58	99.8
rdale	G-9A	9.32	20	.01	.1	.74	20	.04	5.5
			40	1.21	13.0		40	.09	12.5
			60	2.85	30.8		60	.08	11.1
			80	1.42	15.4		80	.04	5.5
			100	1.45	15.7		100	.07	9.7
			100+	2.30	24.9		100+	.40	55.5
				9.24	99.9			.72	99.8
o	G-10A	9.70	20	.17	1.8	.34	20	.05	14.7
			40	3.32	34.2		40	.12	35.3
			60	4.00	41.2		60	.07	20.6
			80	1.07	11.0		80	.02	5.9
			100	.78	8.0		100	.04	11.8
			100+	.37	3.8		100+	.04	11.8
				9.71	100.0			.34	100.1
o	G-11A	9.62	20	.05	.5	.40	20	.01	2.6
			40	2.87	30.1		40	.05	12.8
			60	3.22	33.8		60	.03	7.7
			80	1.05	11.0		80	.02	5.1
			100	.97	10.2		100	.02	5.1
			100+	1.38	14.5		100+	.26	66.6
				9.54	100.1			.39	99.9
ood Road	G-12A	6.24	20	.55	8.9	3.75	20	.04	1.1
			40	2.33	37.6		40	.25	6.7
			60	1.69	27.3		60	1.17	31.5
			80	.67	10.8		80	.86	23.2
			100	.53	8.6		100	1.04	28.0
			100+	.42	6.8		100+	.35	9.4
				6.19	100.0			3.71	99.9
o	G-13A	9.50	20	.50	5.3	.55	20	.19	32.2
			40	5.42	57.4		40	.14	23.7
			60	2.97	31.4		60	.15	25.4
			80	.39	4.1		80	.05	8.5
			100	.15	1.6		100	.04	6.8
			100+	.02	.2		100+	.02	3.4
				9.45	100.0			.59	100.0
o	G-14A	9.65	20	.07	.7	.40	20	.10	25.6
			40	6.12	63.0		40	.04	10.2
			60	2.50	26.0		60	.01	2.6
			80	.46	4.7		80	.02	5.1
			100	.27	2.8		100	.02	5.1
			100+	.29	3.0		100+	.20	51.3
				9.71	100.2			.39	99.9
erton	G-15A	5.27	20	.09	1.7	4.79	20	.18	3.9
			40	1.22	23.0		40	.74	15.4
			60	1.69	32.1		60	.66	13.8
			80	.87	16.4		80	.72	15.0
			100	.80	15.1		100	.95	19.6
			100+	.62	11.7		100+	1.55	32.3
				5.29	100.0			4.80	100.0

The glauconite particles range in diameter from more than to less than 100-mesh, but the greatest number by weight fall 20 and 40 mesh, though many fall between 40 and 60 mesh. the last size the quantity of glauconite falls off rapidly, thou samples, especially G–9A, have considerable material of th sizes.

The quartz grains, too, fall chiefly between 20 and 60 m there is a large percentage also of the finest grains.

SHAPES OF GRAINS.

The largest glauconite grains, 20-mesh or more in diamet their form most clearly. Under the hand lens they appear i botryoidal, or mammillary in general form, suggesting aggr rounded grains, rather than casts of foraminiferal shells, some grains suggest such form. Many appear to be rounded with irregular cracks of lighter color. The grains in genera shiny surface and dark-green color. The 40 and 60 mesh gra similar forms and markings but a greater degree of regular reduced by wear from larger grains. Some of the grains are or curved and have a platy structure or cleavage. The grains are subangular to rounded, though retaining to som the suggestion of earlier form and markings. They have been much worn and represent, at least in part, material that transported and redeposited. Other grains, nonmagnetic, h like or capsule form and measure 40 mesh or less. Thes qualitatively, give a strong reaction for phosphate. Typica nite grains, somewhat magnified, are shown in Plate IV (p.

The quartz grains are generally irregular, angular, or sul ı determinations were all made by the method described by and Bailey.[65]

Analyses and determinations of greensand, etc.

Character of work.	Number of determinations.
O in individual original samples	128
O in combined or prepared samples	17
luble K_2O in original samples	18
dividual or combined samples	15
ndividual or combined samples	13
dividual samples	2
determinations	6
determinations	3
of three samples of water, five determinations each	15
analyses of ten samples, eleven determinations each	110
	327

total potash content of the individual original samples has been in the logs of the respective borings. It has furnished the basis computations and estimates already presented. The density noisture content of the greensand have also been utilized in computations and estimates. Some reference has also been to the determinations of CaO, P_2O_5, and CO_2. Other features investigation are described below.

COMPOSITION OF GREENSAND.

merous analyses of greensand samples from different parts of Jersey are given by Cook.[66] Four of them, which relate to locali- ear those sampled in the present investigation, are given in the ring table:

Analyses of greensand.

	1	2	3	4
ric acid	1.68	1.02	2.69	2.34
ic acid	.96	.27	.26	.21
id	55.93	50.23	49.40	50.00
	5.80	6.32	6.31	6.18
	1.64	1.40	2.52	1.57
a	1.01	3.45	3.25	.60
iron and alumina	24.41			
		7.94	8.90	6.15
f iron		20.14	18.66	24.32
	8.84	9.00	7.55	6.88
	100.27	99.77	99.54	98.25

pper marl bed" (Manasquan) from Joshua Forsyth's place near Pemberton; green marl, an specimen. Cook, G. H., op. cit., p. 435.

iddle marl bed" (Hornerstown), from the Pemberton Marl Co., sent by J. C. Gaskill as an average. . 434.

iddle marl bed" (Hornerstown), from pits of West Jersey Marl & Transportation Co.; average of le bed dug. Idem, p. 437.

ower marl bed" (probably Hornerstown rather than Navesink) from farm of Jesse Lippincott, iman's Creek, Gloucester County; and average of the green marl of this neighborhood. Idem,

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s, W. B., and Bailey, R. K., Methods of analysis of greensand: U. S. Geol. Survey Bull. 660, pp. 18.

k, G. H., The geology of New Jersey, pp. 417-441, 1868.

Much time has elapsed since the publication of Cook's wor there have been changes in methods of analysis, so that it was tl desirable as a check to make a few complete analyses of gre samples taken in the present investigation. Four samples w cordingly selected, the analyses of which are given in the fol table:

Analyses of greensand.

[R. K. Bailey, analyst. For organic matter see p. 130.]

	M-119	M-99	M-52	M-15		M-119	M-99	M-52
SiO_2	68.90	50.74	51.83	50.32	Na_2O	0.82	1.53	0.7
Fe_2O_3	8.91	17.36	17.15	18.38	CO_2	1.00	.88	.3
FeO	1.52	3.34	2.93	3.02	P_2O_5	1.05	1.79	.3
Al_2O_3	3.52	1.93	6.23	7.53	H_2O	7.68	9.08	9.9
CaO	2.10	2.86	.52	.65				
MgO	1.90	3.76	3.66	3.82		100.96	99.95	100.
K_2O	3.56	6.68	6.60	7.88				

M-119. Manasquan marl from hole 17, locality 96, between Birmingham and Pemberton. (
M-99. Hornerstown marl from hole 15, locality 62, Elmwood Road. (See p. 70.)
M-52. Hornerstown marl from hole 10, locality 35, Sewell. (See p. 49.)
M-15. Hornerstown marl from hole 6, locality 13, Woodstown. (See p. 32.)

Although the localities from which the Cook samples were are not definitely known the respective materials represented two sets of analyses may perhaps be regarded as fairly comp Certain differences, however, deserve mention.

The potash content of Cook's samples 2, 3, and 4 seems sight to agree fairly well with that of samples M-99, M-52 and though it is somewhat lower. It does not appear, howeve Na_2O was separately determined in the Cook samples. This sul is therefore probably included in the figure for potash. Furt pointed out by Hicks and Bailey,[67] the methods employed in th yses cited by Cook would tend to give too low a value for the better-grade marls. Some of the P_2O_5 is doubtless combined with iron instead of with lime, for the mineral vivianite occurs at a number of the localities sampled.

Some of the iron is probably present in the form of sulphides or sulphates, as indicated by the sulphuric acid of the Cook samples and by the "irony water" noted at many wells.

COMPOSITION OF PRODUCTS OF WET SEPARATION.

In the section on mechanical analyses of greensand (p. 117) it is suggested that much of the claylike material so abundant in some beds of greensand is really composed of finely comminuted glauconite grains. Four analyses were therefore made for the purpose of comparing the chemical composition of the products of wet separation and of unaltered greensand. The samples used were some of those prepared for mechanical analysis. (See p. 118.) Each represents high-grade Hornerstown marl. The chemical analyses are given in the following table:

Composition of products of wet separation.

[R. K. Bailey, analyst.]

	G-7A (coarse residue, Sewell).	G-7B (fine washings, Sewell).	G-13A (coarse residue, Elmwood Road).	G-13B (fine washings, Elmwood Road).
SiO_2	50.38	49.30	49.50	43.70
Fe_2O_3	18.69	16.33	18.27	15.50
FeO	2.84	2.61	3.03	2.54
Al_2O_3	7.83	8.92	6.52	11.10
CaO	.37	.72	1.77	3.43
MgO	3.54	3.44	3.78	2.99
K_2O	7.85	6.74	7.37	5.73
Na_2O	0.30	0.36	0.26	1.15
CO_2	.10	2.48	.30	4.04
P_2O_5	.28	.61	1.09	(a)
H_2O	8.70	9.22	8.98	10.80
	100.88	100.76	100.87	100.98

[a] No material left for determination of P_2O_5.

These analyses appear to justify the view that the fine or claylike constituents of the greensand marl have practically the same composition as the coarser constituents and that much of the fine material is finely comminuted or amorphous glauconite. When these samples are compared with each other or with samples M-99, M-52, and M-15 of the previous table certain variations appear, but the quantities of the respective constituents are of the same order.

POTASH CONTENT OF THE FINES.

Although it was impracticable to make extended analyses of all the samples of fines obtained by washing (see p. 118), the potash content of each was determined because of its possible bearing on the treatment of the marl in commercial operations. If the fines should prove decidedly lower in potash content than either the coarser residues or the unaltered marl it might pay to wash the ma before extracting the potash. In the preceding table the potas content of the fines is compared with that of the coarser residues. In the following table the potash content of the fines is compared with the average potash content of the unaltered greensand. (See p. 104.) The discrepancy in thicknesses given for the beds in the two tables cited is due to a revision of stratigraphic data after the mechanical analyses were completed. The beds from which the fines were taken correspond in a general way, however, to those fo which the average potash content is given.

Potash content of fines and of unaltered greensand in per cent.

[R. K. Bailey, analyst.]

Locality.	Gray marl.			Green marl.			Chocolate marl.		
	Unaltered.	Fines.		Unaltered.	Fines.		Unaltered.	Fines.	
	K_2O.	Sample No.	K_2O.	K_2O.	Sample No.	K_2O.	K_2O.	Sample No.	K_2O.
Salem	6.19	G-1B	4.73	7.19	G-2B	6.47	....	....	.....
Woodstown	6.12	G-3B	5.27	7.58	G-4B	7.04	6.69	G-5B	5.
Sewell	6.09	G-6B	6.20	7.52	G-7B	6.74	5.99	G-8B	4.
Somerdale	....	G-9B	6.23	7.35	G-10B	7.26	6.32	G-11B	5.
Elmwood Road	6.01	G-12B	4.55	7.26	G-13B	5.73	6.32	G-14B	3.

For the Manasquan marl in the Birmingham-Pemberton area the average of samples M-119, 121, 122, 12 and 125, weighted according to the thickness represented by each sample, was 3.7 per cent of potash, an the fines (sample G-15B) showed 2.89 per cent.

In general the potash content of the fines, as shown in the abov table, runs from about 0.1 to 1.5 per cent lower than in the unaltere

COMPOSITION OF GLAUCONITE.

Cayeux [68] cites a group of analyses showing the chemical composition of actual glauconite. The samples analyzed were all of recent material, mostly taken by the *Challenger* expedition. The analyses are presented in the following table.

Chemical composition of recent glauconite.

	1	2	3	4	5	6	7
SiO_2	56.62	50.85	51.80	55.17	27.74	46.90	47.46
Al_2O_3	12.54	8.92	8.67	8.12	13.02	4.06	1.53
Fe_2O_3	15.63	24.40	24.21	21.59	39.93	27.09	30.83
FeO	1.18	1.66	1.54	1.95	1.76	3.60	3.10
CaO	1.69	1.26	1.27	1.34	1.19	.20	....
MgO	2.49	3.13	3.04	2.83	4.62	.70	2.41
K_2O	2.52	4.21	3.86	3.36	0.95	6.16	7.76
Na_2O	.90	.25	.25	.27	0.62	1.28	....
H_2O	6.84	5.55	5.68	5.76	10.85	9.25	7.00
	100.41	100.23	100.32	100.39	100.68	99.24	100.09

1-5. From *Challenger* reports.

6. Agulhas Bank, Indian Ocean. Gümbel, C. W., K. bayer. Akad. Wiss. Sitzungsber., vol. 16, p. 417, [illegible].

7. Material from *Challenger* office, described by L. W. Collet (Les dépôts marins: Encyclopédie scientifique, p. 167, Paris, 1908) as "the purest specimen of actual glauconite which has ever been found."

The noteworthy features of these analyses are the relatively high percentage of ferric iron as compared with ferrous iron, the relatively high alumina content, and the low or moderate potash content.

Cayeux also cites a list of 23 analyses of glauconite from older sedimentary formations and shows, following other investigators, that these older glauconites, though still ferric, have greater percentages of ferrous iron than the recent types. The analyses also show a considerable increase in the amount of potash and in some at least a diminution in the amount of alumina. Collet [69] remarks that "the glauconite which is forming to-day on the bottom of the sea is not the glauconite of sedimentary rocks, which certainly has undergone transformations that must be studied to understand the genesis of this interesting mineral." These transformations doubtless include the continuation of the process that he terms "glauconitization," to which further reference is made on page 140.

A group of analyses of glauconite from sedimentary rocks, some of which are identical with those given by Cayeux, are cited by

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[68] Cayeux, Lucien, Introduction à l'étude pétrographique des roches sédimentaires: Mém. carte géol. France, pp. 242-244, Paris, 1916.

[69] Collet, L. W., op. cit., p. 168.

Dana.[70] Some of these, together with analyses of material c
in the present investigation, are given in the following table:

Chemical composition of g.auconite from older sedimentary deposits.

	1	2	3	4	5	6	7	G-7
SiO_2	49.42	51.24	49.76	50.62	50.42	46.91	49.09	50.
Fe_2O_3	16.01	13.44	16.00	21.03	19.90	23.06	10.56	19.
FeO	3.00	3.06	3.77	6.02	5.96	2.64	3.06	2.
Al_2O_3	10.23	12.22	8.18	3.80	4.79	7.04	15.21	6.
CaO	.31	.10	.41	[b] .54	3.21	2.95	.55	.
MgO	3.78	3.93	3.97	[b] .57	2.28	4.40	2.65	4.
K_2O	7.91	7.50	7.57	7.14	7.87	7.31	6.05	8.
Na_2O	.26	.31	.52	....	.21	.91	1.21	.
CO_2	....	....	....	....	....	....	....	.
P_2O_5	....	....	....	....	....	....	....	.
H_2O	8.08	8.20	9.82	9.14	5.28	4.71	11.64	7.
Insoluble material	.80	....	....	....	....	....	....	....
	99.80	100.00	100.00	99.86	99.92	99.93	100.02	100.

[a] For organic matter see p. 130.
[b] Carbonates.
1. Swir River, Russia. Kupffer, A., Jahresb. Chemie, 1870, p. 1307.
2. Ontika, Russia. Kupffer, A., idem.
3. Grodno Valley, Russia. Kupffer, A., idem.
4. Havre, France. Haushofer, K., Jour. prakt. Chemie, vol. 102, p. 38, 1866.
5. Antwerp, Belgium. Dewalque, F., Soc. géol. Belgique Annales, vol. 2, p. 3, 1875.
6. Gozzo Island, Mediterranean Sea. Bamberger, E., Min. pet. Mitt., 1877, p. 271.
7. Ashgrove, near Elgin, Scotland. Heddle, M. F., Roy. Soc. Edinburgh Trans., vol. 29, p.

G-7C. Sewell, N. J., Hornerstown marl, glauconite grains separated magnetically from t
of washed greensand. (See pp. 118–119.)

G-13C. Elmwood Road, N. J., Hornerstown marl, glauconite grains separated magneticall
residues of washed greensand. (See pp. 118–119.)

The magnetic separation in the last two samples was ver
so that these samples represent material as nearly pure as i
possible to get by the method given. The potash content is di
higher than that of the other samples cited and is probably
as could be expected from most New Jersey material.
analyses may therefore serve as a further check on the anal
material from Eatontown given on page 97. By comparisc

unt of soluble potash in selected representative samples. hod employed was that given in Bulletin 107 of the Associ- Official Agricultural Chemists. The following table shows total potash and the water-soluble potash of the samples:

Total and water-soluble potash in greensand.

[R. K. Bailey and E. T. Erickson, analysts.]

o.	Locality.	K_2O (per cent).	
		Total.	Soluble.
	Hole 3, Salem	7.72	0.06
	Hole 6, Woodstown	7.88	.04
	Hole 8, Sewell	7.62	Trace.
	do	6.18	Trace.
	Hole 11, Somerdale	7.58	.02
	Hole 12, Somerdale	7.32	.02
	Hole 15, Elmwood Road	6.68	.04
	Hole 16, Elmwood Road	6.36	.06
	Hole 17, near Birmingham	3.61	Faint trace.
	do	3.63	Trace.
	Hole 18, near Birmingham	3.27	None.
	do	2.75	None.
	do	1.83	None.
	Hole 19 near Pemberton	4.29	Trace.
	do	2.90	Trace.
	do	4.61	Trace.
	Locality 60, near Osage Station	7.17	Trace.
	Locality 118, near Eatontown	7.09	Trace.

the above table it appears that the water-soluble potash of greensand is very low. The greensand is thus generally d as unsuited for use in prepared fertilizers, though some of een used in fertilizer as a filler.

ACID SOLUBILITY.

ecial tests of the solubility of greensand in acids were made, nsand is said to be directly and slowly soluble in dilute acids ric, hydrochloric, or even acetic), so that the potash becomes e.

SOLUBILITY AND AVAILABILITY.

ugh the availability of fertilizer ingredients is generally d to depend on their solubility, greensand appears to offer ption to this rule. Its wide and beneficial use as a fertilizer er years lends strong probability to the idea that its potash, practically insoluble in water, is actually available for plant Possibly the weak acids present in some soils or the local between the greensand and the root activity of certain nay bring about this condition. Experiments of True and f the United States Department of Agriculture, on the lity of potash in greensand have been described on pages .

ORGANIC MATTER.

In the analyses reported on pages 124 and 128 organic ma was inadvertently omitted. For the sake of completeness this later determined for the four samples of greensand and for two the magnetically separated samples of glauconite. In the determ nations, which were made by E. T. Erickson in the laboratory the United States Geological Survey, the sample was treated initial with dilute sulphuric acid with some boiling to eliminate inorga carbon dioxide. Possibly a slight and negligible amount of orga matter escaped in this treatment. The residue was then heat nearly to the boiling point of an aggregate of about 50 per ce H_2SO_4 and 10 per cent Cr_2O_3. The following determinations organic carbon were calculated from the carbon dioxide recove from this procedure:

Organic carbon in samples of greensand and glauconite from New Jersey.

	Per cent.
Greensand:	
M-15	0.07
M-52	.24
M-99	.10
M-119	.21
Glauconite:	
G-7C	.10
G-13C	.09

Mr. Erickson states that for stabilized organic matter—that organic matter not of recent origin—the hydrogen content may considered as considerably less than the corresponding amounts carbon and very likely not over one-fifth of that of the orga nce of these substances in the marl. Cook[71] emphasized the nce of the phosphoric acid in these words:

> ioric acid is the most valuable constituent of the whole. Indeed, it may be s a general truth, that the greensand marls may be valued just in proportion rcentage of this acid they contain.

at day the effect of potash on plant growth was just beginning alized. In the light of the experiments of True and Geise it ems probable that the potash in the marl is sufficiently avail- have agricultural importance at least equal to that of the oric acid.

average phosphoric acid content of New Jersey greensand s shown by 130 analyses given by Cook[72] is 1.78 per cent. ly the average lime content derived from 105 of Cook's analy- .25 per cent. The highest individual percentage of phosphoric ed by him was 6.87 in a sample from the upper marl (Manas- from Poplar. The highest percentage of lime (not counting ported as carbonate) was 15.19 in a sample from the lower avesink) from Holmdel.

y recent analyses cited on pages 95, 96, and 98 give 0.907 per phosphoric acid as the average of ten samples of Navesink marl e Marlboro district, 0.96 per cent as the average of three sam- Hornerstown marl from Freehold, and 1.16 per cent as the e of seven samples of Manasquan marl from Farmingdale. lyses of three composite samples of Manasquan marl from the gham-Pemberton district, made in connection with the present gation and given on page 88, show from 1.37 to 3.58 per cent sphoric acid and from 1.53 to 3.86 per cent of lime. Addi- analyses of selected individual or composite samples from the rstown and Navesink marls are given in the following table:

Lime and phosphoric acid in selected samples of marl.

[R. K. Bailey and E. T. Erickson, analysts.]

No.	Locality.	Formation.	CaO	P_2O_5
			Per cent.	*Per cent.*
....	Hole 3, Salem	Hornerstown	2.97	0.68
7a...	Hole 6, Woodstown	do	.40	.25
....	Hole 9, Sewell	do	.07	Trace.
....	Hole 10, Sewell	do	.52	.31
....	West Jersey Marl & Transportation Co.'s pit, Sewell	Navesink(?)	.20	Trace.
....	do	Hornerstown	1.49	.38
....	Hole 12, Somerdale	do	.17	.17
....	do	Navesink(?)	.08	.15
....	Hole 15, Elmwood Road	Hornerstown	2.86	1.79
....	Atlantic Potash Co.'s pit, Marlton	do	1.84	1.24
....	Coplay Cement Co.'s pit, near Osage	do	None.	.33
....	Eastern Potash Corporation's ground, near Eatontown.	do	None.	.20
			1.08	.56

osite sample of one-third each of M-15, M-16, and M-17.
osite sample of one-half each of M-78 and M-79.

, G. H., op. cit., pp. 453-454.

, pp. 417-441.

The phosphoric acid and lime content of the three pri beds in New Jersey is relatively low, but the Manasquan greater proportion of these substances than the other tw the other hand, as previously noted, it is poorer in potas

ACCOMPANYING WATER.

At many localities the marl beds contain water, espec southwestern part of the State, where the elevations a lower than in the northeastern part. Much of the water pleasant taste of iron or is slightly sulphureted and is drinking. One sample of about 2 quarts was collected at Woodstown. A number of samples of marl collecte thought to contain sufficient water, singly or as com analysis. The waters, however, proved insufficient for t Probably a gallon of each sample would be required f analyses.

By combining the supernatant water from 11 sampl M-108 inclusive) from hole 15 and similarly the water fr ples (M-109 to M-118 inclusive) from hole 16, both a Road, sufficient liquid was obtained for partial analyses, sent the waters from these holes. The analyses of thes samples and of sample 24 from hole 7, at Woodstown, the following table. Only four of the more important were determined in each sample.

Partial analyses of water samples from New Jersey greensan

[R. K. Bailey, analyst.]

	Hole 15, Elm-	H

In laboratory determinations of water-soluble potash it is custom-
ry to boil the material in water for perhaps half an hour to pro-
ice the solution, whereas in the ground solution takes place at a
uch lower temperature and hence much more slowly. On the
her hand, the water which percolates slowly through the beds has
advantage of long-continued contact with the greensand.

The disparity between the amount of potassium present and the
ount required for saturation suggests that potassium is being
hdrawn from solution. The silica, lime, and soda and the rela-
ly large percentage of undetermined substances suggest that the
er constituents of glauconite may be present in sufficient quantity
unite with potassium to form glauconite and that this action may
he cause of the withdrawal of potassium from solution.

hat other substances are formed as well is shown by the occur-
ce here and there of vivianite, marcasite, iron carbonate, and
sphatic nodules.

olution and deposition are processes that have doubtless been
ng on within the marl beds at different places at the same time
at the same place at different times. The present composition of
waters represents the balance between the two sets of conditions
the time of sampling.

ENRICHMENT.

POTASH.

ook[73] states that "the best marls will always be found below
natural drainage of the country, or at least where they have
ver drained out to dryness." This statement does not seem to be
ne out by the present investigation. In the table summarizing
field data obtained in the borings (p. 104) the thickness and
ash content of each of the principal marl beds are given for each
ality. The green and chocolate marl beds were in large part or
irely below the water table in four of the five localities. At the
nerdale borings, however, all the marl beds were above the water
le and were practically dry, yet the potash content of each of the
beds represented (the uppermost bed had been eroded) was
nparable to that of the corresponding beds at the other localities.
r example, the green marl at Somerdale contained slightly less
ash than that at Sewell and Woodstown but more than that at
em and Elmwood Road.

The borings show that the green marl averages 1.1 to 1.28 per cent
re in potash content than the other two beds. This difference
pears to be due, in part at least, to its relatively less admixture of
artz. This is shown on the table on page 119, where the results

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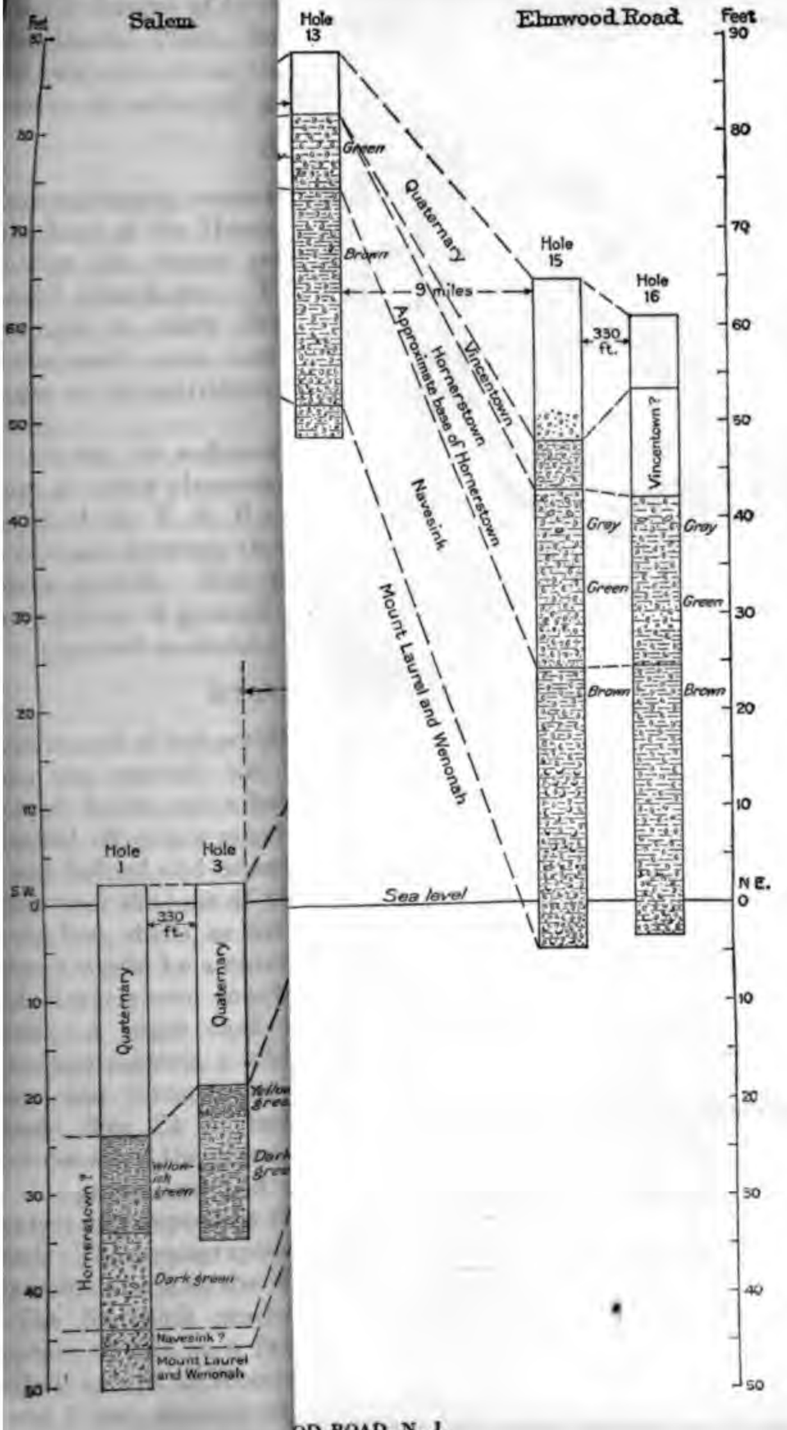
[73] ook, G. H., op. cit., p. 464.

of the magnetic separation of residues are given. Thus it is prob
in the main a feature of original bedding rather than of subsequ
enrichment. The green marl is usually distinct lithologically f
the overlying or underlying bed. This again is probably a feat
of original bedding.

At some localities, however, notably at Sewell (see pp. 47–
there is clear evidence of leaching and oxidation of the upper
of the marl and consequent impoverishment in potash. Altho
the marl beneath has a distinctly higher potash content it is
clear that this is due to enrichment rather than to original de
tion. At the Somerdale borings (pp. 7, 61–64) the Hornerstown
has been in part eroded and is overlain by reworked marl of Qu
nary age. This reworked material is distinctly oxidized and cont
less potash than the uneroded marl beneath, but this uneroded m
which is part of the green bed, is not unduly high in potash.

Without doubt potash is locally being leached from the
and is passing into solution. With little doubt, too, as sugg
above, it is being abstracted from solution, but there seems to b
readily distinguishable zone of enrichment unless the green marl
may be so considered. With regard to what becomes of this po
the following tentative suggestions are worthy of attention:

1. Clay, which is believed to have an important share in
formation of glauconite (see section on nature and origin of g
conite, pp. 138–142), was probably abundant in the original m
from which the glauconite was formed—witness the alumina pre
in all the analyses of glauconite and greensand cited above. It
probably more abundant in some beds than others. Thus the g
marl bed with less quartz probably had a larger proportion of


Feet
Salem
Hole 13
Elmwood Road
Feet
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
Green
Brown
Quaternary
Vincentown
Hornerstown
Approximate base of Hornerstown
Navesink
Mount Laurel and Wenonah
9 miles
Hole 15
Hole 16
330 ft.
Vincentown ?
Gray
Green
Brown
Sea level
S.W.
N.E.
Hole 1
Hole 3
Quaternary
Hornerstown ?
Yellowish green
Dark green
Navesink ?
Mount Laurel and Wenonah

OD ROAD, N. J.

The changes of level to which the marl beds, together with the ire Coastal Plain, have been subjected have permitted all the rl beds, even those that now lie above the water table, to be sub- ted to the action of ground water for protracted periods.

OTHER SUBSTANCES.

on carbonate, somewhat phosphatic, forms the hard, stony layer he base of the Hornerstown marl at hole 7, at Woodstown, and ably also forms part of certain nodules and casts that are gly phosphatic. The stony layer is localized at a horizon that ought to mark the boundary between two formations. The les and casts are distributed rather irregularly. All bear ess to the activities of solution and deposition in the circulating rs.

onstone, or sedimentary material cemented by oxide of iron, rs at many places and at a number of horizons—for example, at pit of the R. S. Ryan Co. near Medford. Here it occurs along contact between the Hornerstown marl and the overlying Qua- ary gravels. (See p. 80.) This material also bears witness to activities of ground water. It is locally of sufficient abundance e quarried as stone.

STRATIGRAPHIC NOTES.

uthwest of Sykesville, in Burlington County, two broad lithologic s are present—an upper formation, predominately green to nish black, and a lower formation, brown to brownish black, the alled chocolate marl. The contact between the two formations ell defined and usually marked by the presence of sand or gravel ns near the base of the green formation. Locally a water-bearing el bed, shells, or an indurated layer occur at the contact. This act would be a convenient lithologic boundary for the Navesink Hornerstown marls and is tentatively so considered in this er. A single cast thought by T. W. Stanton to be that of *ullaea vulgaris*, a wide-ranging form but common in the Horners- n, was taken from a gravel bed at this contact at Elmwood d. (See Pl. X, hole 16.) It suggests that the Hornerstown des all of the green formation at that locality.

his gravel bed and the sand and gravel grains elsewhere at the act may represent the southwestern continuation of the Redbank l. The stratigraphic features of the combined Hornerstown and esink marls at the different borings are shown in Plate X.

he Navesink grades downward into the Mount Laurel but ears to rest on a fairly uniform surface at each of the localities ed, except at Woodstown and Sewell, where variations of about d 5 feet, respectively, in distances of 330 and 375 feet down the dip were observed. These figures would indicate a dip of 64 a feet to the mile, respectively, at these localities, whereas the av calculated by Knapp, as previously stated, is only 33 feet. apparently greater local dip may prove to be more widespread, may indicate local current scour in the Mount Laurel sands pr the deposition of the Navesink.

The thickness of the Navesink is about 28 feet at Elmwood] 23 feet at Somerdale, 17½ feet at Sewell, 14 feet at Woodstowı 2 feet (?) at Salem. At Salem there is no very clear basis fo tinction between the Navesink and Hornerstown. The shel with rice gravel at the base appears to be Navesink, but the above in quality and appearance suggests Hornerstown rather Navesink. At Sewell a depression in the top of the forn corresponding to that in which the base lies was observed Woodstown a depression of 5 feet was found in a distance (feet along the strike, together with a total observed variatioı feet in thickness at the three holes. These features, togetheı the scant representation of the formation at Salem, may in local erosion of the upper beds by current scour or otherwise the other hand, at several of the holes the upper beds of the f tion show a transition interval of 6 inches to several feet in streaks of green material are intermingled with the brown.

In general the Navesink marl is more clayey at the top, less c and correspondingly more glauconitic in the middle, and more near the base. The less clayey portions slump easily and tend t like quicksand. At Woodstown a water-bearing gravelly laye encountered at hole 7, which was not represented at holes 5 a At Sewell a hard sandy layer with vivianite was found in h itic and darker below. Near the base sand and gravel grains and cally even tiny pebbles appear. Local variations may be noted. For example, at Woodstown a stony layer about 6 inches thick, somewhat phosphatic and containing much iron carbonate, occurs at the base in hole 7 but is not found in holes 5 and 6. Similarly, at Woodstown shells were present at the base in holes 5 and 7 but absent in hole 6. At Sewell a light-green clayey bed 4 feet thick at hole 8 is only 6 inches thick 375 feet away at hole 10. Other variations in color and texture were noted at different localities and at different holes in the same locality.

The three holes bored in the Manasquan marl near Pemberton were not deep enough to pass through the formation, but they showed some variations in character and thickness of the marl. The uppermost member, a relatively light colored sandy clay with comparatively little glauconite, was 3 feet thick at the first hole and more than 4 feet thick at the second, only 330 feet distant. The lower, dark-green glauconitic member was more than 9 feet thick at the first hole and less than 3 feet thick at the second. At the third hole, which was nearly a mile and a half away, only the dark-greenish member was exposed, more than 15 feet thick.

These irregularities in the greensand beds suggest that their accumulation did not take place entirely beyond the range of wave and current action.

CONDITIONS OF SEDIMENTATION.

The bedding of the greensand, as previously noted, is generally regular, so far as observed. Some beds show a fine lamination. There is more or less alternation of clayey layers with more glauconitic beds. Quartz grains, generally angular or subangular rather than rounded, are distributed somewhat unevenly throughout the glauconite beds. The sizes of the quartz grains agree in a general way with those of the glauconite, but the preponderance of the 40 and 60-mesh grains is less marked. The specific gravity of glauconite is slightly less than that of quartz, so that under the same conditions of sedimentation the glauconite grains might be expected to have a somewhat greater average size.

The distribution of the quartz grains indicates a generally steady but slow influx of land-derived material from which the more soluble rock fragments had largely been removed. The presence of the clay and glauconitic mud included with the greensand indicates generally quiet waters. The maintenance of these conditions long enough to build up such an extensive and relatively thick deposit suggests a slow subsidence of the bottom on which the deposits were accumulating or a gradual transgression of the sea upon the land. The

Vincentown and Redbank sands indicate that the glauconi
agencies were at times interrupted or impeded by reversa
tions, the sea retreating or becoming shallower during th
their formation. Minor reversals or oscillations of conditi
the deposition of the greensand are indicated by the prese
sandy or gravelly layers described above.

The local variations in the thickness of the supposed Nav
previously mentioned suggest that from time to time the
quiet bottom conditions were disturbed by oceanic curr
waves.

A rather abundant and varied life inhabited the waters in
greensand beds were being deposited, as shown by the shells
types of fossils that have been recovered from the marl beds
these fossils are given by Clark[74] and Weller.[75] These ar
nished by their decay the organic matter generally supp
necessary for the formation of glauconite.

According to Murray and Renard,[76] glauconite forms m
antly at about the lower limits of wave, tide and current
the neighborhood of what may be called the mud line—
about 200 to 300 fathoms. The temperature of the ocea
depths off Sandy Hook is between 40° and 45° F. If, as se
able, the conditions of the formation of glauconite in Creta
were similar to those of to-day the depth of the sea water
Jersey in the Navesink and Hornerstown epochs was 1,20
feet.

NATURE AND ORIGIN OF GLAUCONITE.

Glauconite is a constituent of various marine sediments n
along the shores of the continents, usually at depths greate

ae doubt whether the mineral is really a definite substance. It is
) thought that glauconite may include members of a series of
ierals, in the same manner as the chlorites and micas.[77] Glauco-
) is essentially a hydrous silicate of iron and potassium and, ac-
ding to Clarke,[78] probably has when pure the composition repre-
ted by the formula $Fe'''KSi_2O_6$.aq., in which some iron is re-
ed by aluminum, and other bases partly replace K. Thus it
uld contain about 13 per cent of potash.[79] The analyses show,
rever, that the potash is practically always partly replaced so that
arely exceeds 7.50 to 8 per cent. Dana[80] gives the hardness of
ıconite as 2 and its specific gravity as 2.29–2.35. It is usually
orphous and has a granular texture.

lauconite occurs chiefly in tiny irregular botryoidal or rounded
ins, some of which appear to be casts of foraminiferal or other cal-
eous shells. The greater number, however, show no direct rela-
ı to foraminiferal form. Many of the grains are worn and have
iently been transported and redeposited. Cayeux[81] describes and
res a type of grain relatively rare, in which a thin superficial coat-
with radial structure, visible only in thin sections with strong
gnification, was observed. Collet[82] suggests that these coatings may
resent glauconitic pseudomorphs after the calcite of foraminiferal
ls. Another type of grain described by Lacroix[83] and relatively
ı is thought to be crystalline and monoclinic. It is strongly pleo-
ic, has a well-recognized cleavage, and under crossed nicols in
ırized light extinguishes parallel to the cleavage. Still another
e, called by Cayeux pigmentary glauconite, stains the cement of
solidated sediments and forms coatings on grains of other minerals
illings in the cracks of minerals such as feldspar.

. number of microscope slides were made showing thin sections of
ıconite and of some of the associated mineral grains of different
s from the New Jersey borings of the present investigation. The
eworthy features of the glauconite, as shown in these sections,
(1) the absence of concentric or radio-fibrous structure; (2) the
ence of any skeleton or core of other mineral matter; and (3) a
orm or nearly uniform aggregate structure of tiny crystalline

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flakes, which, in polarized light, show an aggregate polarization without general extinction. (See Pl. IV, p. 6.)

The absence of skeleton or core is in distinct contradiction to the idea of Hart[84] that glauconite "consists of a core, which is apparently pure silica, and a covering layer of glauconite containing apparently no, or very little, silica."

Some grains, presumably those described on page 122 as having a platy structure or cleavage, show these features with parallel extinction in thin sections and are pleochroic. These may prove to be crystalline glauconite like that described by Lacroix. A grain of feldspar, in which flakes of glauconite had evidently been formed in cracks, was observed in one of the sections. The glauconite was apparently fresh and relatively pure and free from alteration. A few grains, however, showed encroachment of iron sulphide. The seed-like or capsule-shaped grains are isotropic. They are phosphatic and contain numerous tiny black particles that may be magnetite. Some of them contain grains of green glauconite.

The origin of glauconite is still imperfectly understood. According to Murray and Renard,[85] organic matter inclosed in the shells and present in the mud itself transforms the iron in the mud into sulphide, which may be oxidized into hydrate, sulphur being at the same time liberated. The sulphur becomes oxidized into sulphuric acid, which decomposes the fine clay, setting free colloid silica, alumina being removed in solution. The colloid silica and hydroxide of iron are in a condition most favorable for their combination, and in the presence of potash salts in sea water these substances form glauconite. Collet[86] suggests in modification of these views three stages for which he cites evidence—(1) the formation of gray casts composed exclusively less irregular manner, as in the formation of concretionary ces. Although the irregularities of shape and the general of grains with definite foraminiferal form may perhaps be ›d in this way, the coatings and accretionary layers noted that other modes of origin besides that within calcareous ıay be important.

ıx[88] cites a variety of evidence to show that organic matter is ential to the origin of glauconite grains. He ascribes an nt share in their genesis to the so-called pigmentary glaucon- shows that grains of glauconite have originated or have ed to increase in size after all the elements of the accompany- iments were in place as in a consolidated deposit. He con- hat organic matter may be more often the primordial condition roduction of glauconite, but that it is very certain in many hat organic matter has had no part in the genesis of this .

t[89] also recognizes the important part that pigmentary ite may play in the origin of glauconite grains and adds that ence of cement in microscopic sections of glauconite may be ed by the fact that both the glauconite grains and the glau- cement are cryptocrystalline and composed of particles tly oriented so that suture lines would be masked.

ıge 126 the fine material washed from composite samples of rsey greensand beds is shown to contain approximately 3 to 7 ıt of potash. It consists largely of greenish to yellowish l matter that may be classed as pigmentary glauconite. be part of the original deposit, in which for some reason of glauconite did not develop, or it may have originated by ical wear or disintegration of previously existing grains. , however, have been formed by the chemical action of the ing waters upon clay in the marl. Possibly grains of glaucon- be forming in it to-day, but of this no direct evidence was d.

reference to celadonite, a mineral closely related in composi- glauconite, Clarke[90] remarks:

> r, we assume that celadonite and glauconite are at bottom the same ferri- ilicate, differing only in their impurities, we may begin to see that the several its formation are not absolutely different after all. Probably, in all their ›es, the final reaction is the same, namely, the absorption of potassium and sol- a by colloidal ferric hydroxide. In the ocean these materials are prepared tion of decaying animal matter upon ferruginous clays and fragments of potas- ring silicates. In the sedimentary rocks, where glauconite appears as a late

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;, Lucien, op. cit., pp. 176-184.

L. W., op. cit., pp. 154, 155.

F. W., The data of geochemistry: 4th ed.: U. S. Geol. Survey Bull. 695, pp. 514-515, 1920.

> product, the action of percolating waters upon the hydroxide would accoun formation. In igneous rocks the hydroxide is derived from augite, or perh olivine, and percolating waters again come into play. Thus the various pro of glauconite and celadonite become the results of a single process, which is equivalent to that in which potassium compounds are taken up by clays. Th vation of L. Cayeux that glauconite is frequently present in arable soils, in a tions from perfect freshness to complete alteration into limonite, suggests that the formation of the species is one of the modes by which potassium is withdra its solution in the ground waters.

This statement tends to confirm the suggestions presented in the discussion of enrichment.

Fuller discussions of the nature and origin of glauconite ar in some of the papers cited, notably those of Cayeux and which contain bibliographies of the subject.

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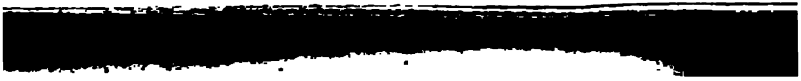

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS.
IN COOPERATION WITH THE DEPARTMENT OF CONSERVATION AND
DEVELOPMENT OF NEW JERSEY.

OIL SURVEY OF THE BERNARDSVILLE AREA, NEW JERSEY.

BY

STIN L. PATRICK, In Charge, and E. B. DEETER, of the
U. S. Department of Agriculture, and C. C. ENGLE and
L. L. LEE, of the Department of Conservation and
Development of New Jersey.

[Advance Sheets—Field Operations of the Bureau of Soils, 1919.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1923.

[PUBLIC RESOLUTION—NO. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the

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XVI. Fig. 1.—Flat topography of the Penn silt loam. Fig. 2.—Pear orchard and hay field on Penn silt loam

FIGURE.

FIG. 9. Sketch map showing location of the Bernardsville area, New Jersey..

MAP.

Soil map, Bernardsville area sheet, New Jersey.

SURVEY OF THE BERNARDSVILLE AREA, NEW JERSEY.

N L. PATRICK, In Charge, and E. B. DEETER, of the U. S. Depart-
Agriculture, and C. C. ENGLE and L. L. LEE, of the Department of
tion and Development of New Jersey.

DESCRIPTION OF THE AREA.

rnardsville area, comprising nearly all of Morris and Somer- ies and small parts of Middlesex, Union, Essex, Sussex, and n Counties, is situated in the cen- of northern New Jersey. In out- area is rectangular. Its length d south is 32 miles, and its width 23 miles. Its land area is 725 iles, or 464,000 acres.[1]

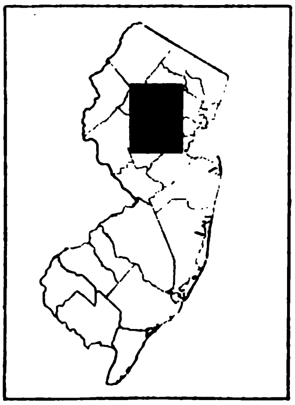

FIG. 9.—Sketch map showing location of the Bernardsville area, New Jersey.

ysiography of the area varies con- and includes low-lying plains, t ridges, and high uplands cut by leys. It consists of three physio- ivisions, or geographic provinces— 'lain, Piedmont Plain, and High- See Pl. XIV.)

astal Plain part of the area is lo- both sides of the Raritan River ew Brunswick and south of Me- ı the extreme southeastern corner a. It ranges in elevation from sea level to 100 feet above and has a gently sloping to nearly flat topography.

edmont Plain occupies all of the remaining part of the Ber- area except the northwestern quarter. It consists of a broad, t to gently rolling region cut rather deeply by the larger nd broken in the northeastern and east-central parts of the he high curving ridges of the Watchung Mountains and in me southwest corner by a point of Sourland Mountain. untains rise abuptly from 200 to 400 feet above the general he region.

ighlands occupy the northwestern section of the area and f high, rolling, plateaulike country cut deeply by many

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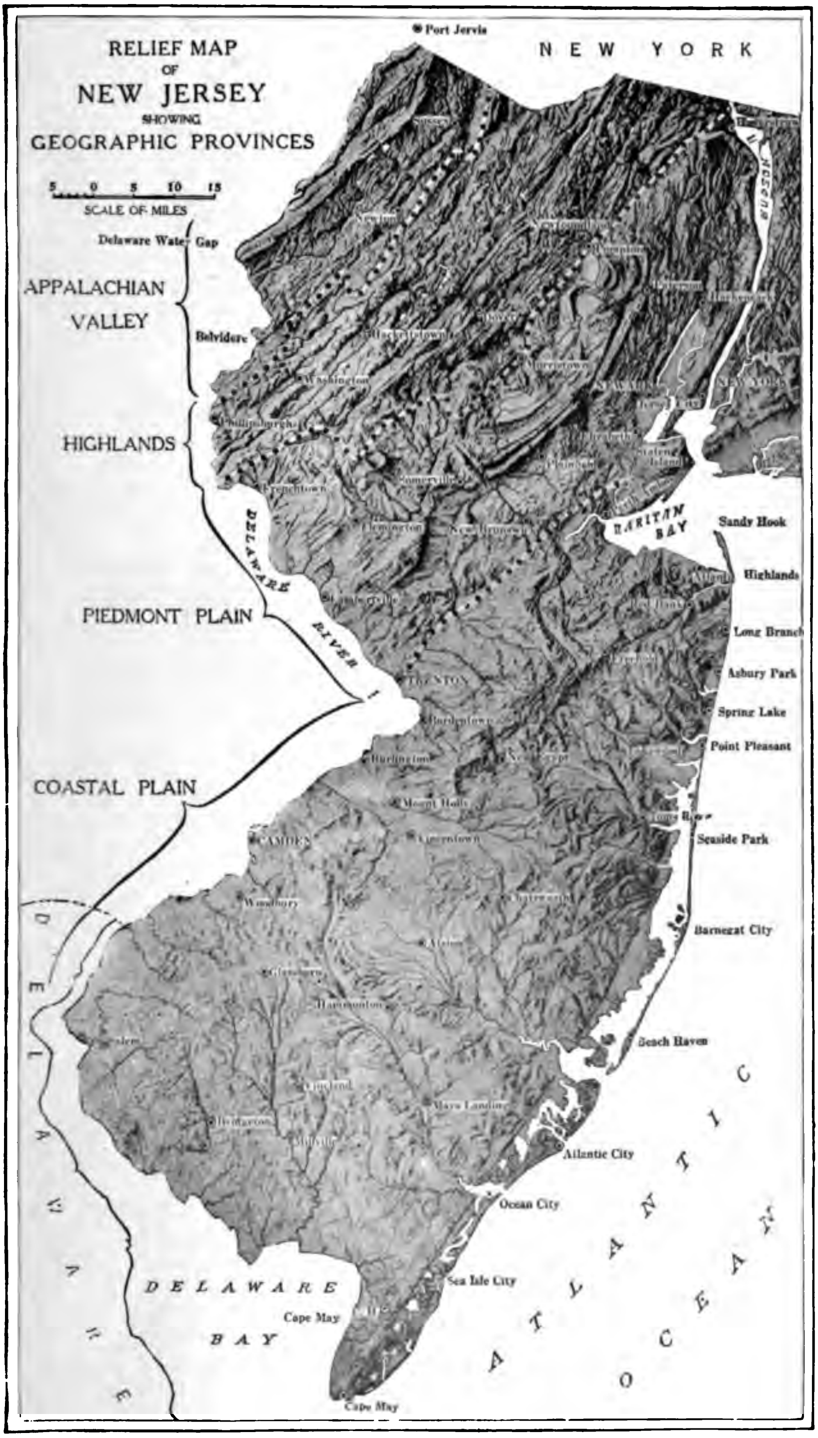
map used is sheet No. 25 of the New Jersey State Topographical Atlas.

streams and rather narrow stream valleys, the widest of which is an extension of the Raritan Valley near the headwaters of the south branch of the Raritan River. The general elevation of this section is between 900 and 1,000 feet above sea level, though there are a number of knolls which have an elevation of over 1,200 feet. The elevation of the valleys is from 300 to 400 feet lower. The slopes and valley sides are as a rule steep and rough.

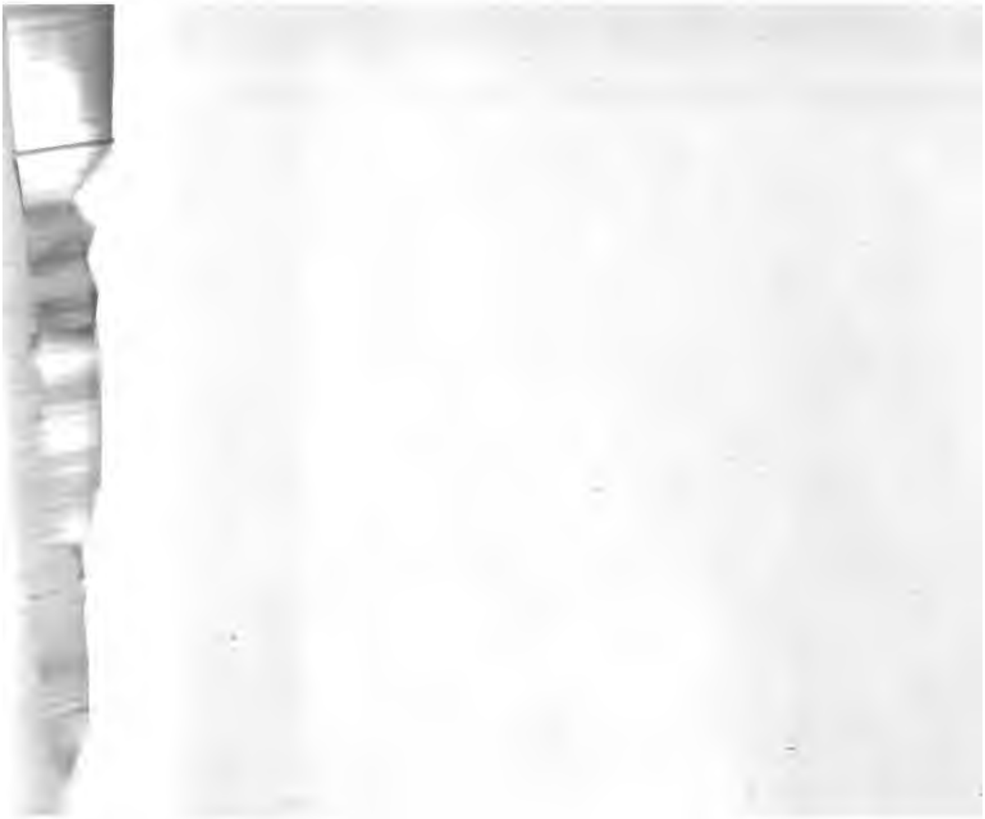
The surface drainage of the area enters the Atlantic Ocean through the Raritan and Passaic Rivers. The northwestern and southern sections drain into the Raritan River. Both the north and south branches of the Raritan head in the northwestern part of the area. The most important tributaries of the Raritan are the Black or Lamington River, Rockaway Creek, and Millstone River. The general course of the Raritan is south and southeast. The Passaic River and its tributaries, of which the Rockaway and Whippany Rivers are the most important, carry off the surface waters of the northeastern and east-central sections. The general slope is north to northwest, but the river changes its direction many times before it finally empties into Newark Bay.

The region lying in the Raritan drainage basin as a whole is well drained, but the Passaic basin includes numerous large swamps, among which Great Swamp, Black Meadows, and Troy Meadows are the largest. In the Highlands and Piedmont sections many of the streams have cut their valleys and channels 200 to 400 feet below the general level of the surface. The valleys are deeper in the Highlands than elsewhere. The streams are still actively cutting down, and water power could be developed in many places. Many old mills have been in operation in the past.

Report of Bureau of Soils, U. S. Dept. of Agriculture, 1919. **PLATE XIV.**



GEOGRAPHIC PROVINCES OF NEW JERSEY.



ast Jersey and William Penn and his associates in West Jersey. e Boards of Proprietors still retain corporate existence, with s at Perth Amboy and Burlington, respectively.

1682 East Jersey was divided into four counties, Bergen, Essex, llesex, and Monmouth. Somerset was cut off from Middlesex in , and additional territory was given it at the expense of Middlein 1709. Union County was later set off from Essex County, Morris County was set off from Hunterdon County. At first is County was nearly all in West Jersey, but later, according e boundary line agreed to by the two provinces, all of Morris ty except the western part was given to East Jersey.

e earliest settlements were made in the southeast and southal part of the area, on land now included in Middlesex, Union, Somerset Counties, between the years of 1650, or before, and . Morris County was settled shortly afterwards. The English, ch, New Englanders, Dutch, and Germans all played important in the early settlement. Many of these early settlers were ers. Some of the very earliest settlements were made at Piscat, Bound Brook, Plainfield, Scotch Plains, Pluckemin, Hanover, ppany, and Basking Ridge.

e descendants of many of the original settlers live in the section y. Of late years an increasing number of foreign-born whites Russia and southern Europe have settled here, particularly in near the industrial towns of Dover, Morristown, Plainfield, erville, New Brunswick, and Raritan. They are more numerous e towns, but they also constitute the greater proportion of the k farmers or market gardeners near these towns.

cording to the census of 1920, the population of Somerset ty is 47,991 and that of Morris County is 82,694. One-half of people in Somerset County and 50.4 per cent in Morris County in towns with populations of 2,500 or more. The average rural lation per square mile in Somerset County is 78.7 persons, and orris County the average per square mile is 86.4 persons. The s of Union and Middlesex Counties included in the area are much e thickly populated than those of the greater part of the area, g to their location with reference to New York and other cities. ccording to the 1920 census, the largest towns in this area, which ains hundreds of towns, are the following: New Brunswick, ty seat of Middlesex County, with a population of 32,779, comes ; Plainfield is second with 27,700 persons; Morristown, the ty seat of Morris County, has a population of 12,548; Summit, 74; Dover, 9,803; Westfield, 9,063; Somerville, the county seat omerset County, 6,718; and Boonton, 5.372. The towns are both industrial and commuting centers. Many of the inhabitants work in New York and other near-by cities and go back and forth daily on the trains.

The area is exceptionally well supplied with railroads, trolleys, and improved highways. Most of the important railroads connecting New York City with the southern and western sections of the United States traverse this area. Among these are the Pennsylvania, Baltimore & Ohio, Philadelphia & Reading, New Jersey Central, Lehigh Valley, and Delaware, Lackawanna & Western. In addition there are many branch lines, so that all parts of the area are well served with railroad transportation. The counties and the State have built numerous excellent roads and are planning the construction of many more.

In addition to the numerous towns in the area, the cities of New York, Newark, Jersey City, and Hoboken and their suburbs are within 30 miles of the center of the area, so that the farmers have ready access to markets for their produce.

CLIMATE.

The climate of the Bernardsville area is characterized by cold winters and moderately warm summers. The coldest temperature ever recorded was −21° F. in the month of January, and the warmest or the absolute maximum was 109° F. in the month of September. Such extreme temperatures are very unusual, for even in the very coldest months the thermometer seldom remains below zero for more than a day or two at a time, and during the summer it seldom registers 100° F. and never remains that warm for many days. The mean temperature during the winter months for the whole area is growing season averages 181 days from April 19 to October 17. This amounts to a difference of 24 days, or four-fifths of a month. A still greater difference would be shown if records were available for the extreme northern sections at higher elevations than Dover. The length of the season has a marked effect on the growing of crops.

Often corn will fail to mature in the northern part of the area and fruit buds will be killed, when these crops succeed in the southern part. More hardy, quicker maturing varieties are in common use in the northern part. Thus, on the higher elevations many of the farmers plant rye instead of wheat and flint corn for grain instead of the softer or dent varieties. Some damage is done each winter by alternate thaws and freezes. Clover, alfalfa, wheat, and rye sometimes "heave" and winterkill.

The following tables give the more important climatic data recorded at the Weather Bureau stations at Somerville and Dover.

Normal monthly, seasonal, and annual temperature and precipitation at Somerville.

[Elevation, 60 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1902).	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	31.9	67	-18	3.57	2.37	7.71	4.6
January	29.2	70	-20	3.48	3.48	2.94	8.8
February	30.0	68	-12	3.55	1.03	5.77	11.2
Winter	30.4	70	-20	10.60	6.88	16.42	24.6
March	36.9	85	-4	3.95	3.19	4.49	6.2
April	48.7	95	15	3.55	4.46	3.73	.4
May	60.1	99	26	4.12	3.22	1.84	.0
Spring	48.6	99	-4	11.62	10.87	10.06	6.6
June	69.2	102	37	4.15	3.36	5.33	.0
July	73.9	107	45	5.13	4.67	5.52	.0
August	71.9	102	43	4.71	2.91	8.30	.0
Summer	71.7	107	37	13.99	10.94	19.15	.0
September	65.3	109	29	3.66	.70	5.72	.0
October	53.4	95	20	3.41	3.89	6.71	.0
November	42.2	79	7	3.39	3.32	1.41	2.2
Fall	53.6	109	7	10.46	7.91	13.84	2.2
Year	51.1	109	-20	46.67	36.00	59.47	33.4

Normal monthly, seasonal, and annual temperature and precipitation at Dover.

[Elevation, 600 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1903).	Snow, average depth.
	°F.	*°F.*	*°F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	30.1	62	−14	4.12	2.98	5.25	7.0
January	26.6	66	−21	4.49	4.04	4.79	12.5
February	26.2	60	−10	4.24	.77	4.05	15.2
Winter	27.6	66	−21	12.85	7.79	14.09	34.7
March	34.9	83	−4	3.90	2.11	5.49	8.0
April	47.3	93	14	3.51	5.22	4.34	1.3
May	58.6	99	27	4.14	2.66	.37	.0
Spring	46.9	99	−4	11.55	9.99	10.20	9.3
June	67.2	100	37	4.12	3.94	15.02	.0
July	71.4	102	42	5.48	3.97	5.47	.0
August	69.2	100	40	5.00	2.37	9.04	.0
Summer	69.3	102	37	14.60	10.28	29.53	.0
September	62.6	99	28	4.48	.64	3.39	.0
October	50.7	89	19	4.00	4.16	10.77	.0
November	40.3	76	8	3.63	2.47	1.27	3.1
Fall	51.2	99	8	12.11	7.27	15.43	3.1
Year	48.8	102	−21	51.11	35.33	69.25	47.1

AGRICULTURE.

apart. These were gradually extended to the present-day systems. With the construction of the main railroads the real agricultural development of the region began.

Cattle raising has always been an important branch of agriculture, owing to the good natural growth of grasses. The different changes in this form of industry have kept pace with the development of the means of transportation. Thus, meat production was the first object of the cattlemen; slowly dairy cows were substituted for the beef animals, and butter and cheese came to be the important products. To-day the Holstein blood is predominant, since the object is to obtain whole milk. Sheep and hog raising has decreased, although nearly every farmer raises enough pork to supply home needs and in many cases has a surplus to sell. Sheep are not raised to any great extent because of trouble with dogs.

Peach growing was of primary importance a few years ago. In 1890, in Somerset County alone, there were 539,243 trees, but in 1910 the number had decreased to 70,258, and in 1920 the number of trees of bearing age reported was 72,947, with 18,727 nonbearing trees. This has been due largely to the development of the large peach-producing centers on the sandier soils of southern New Jersey and to lack of proper treatment. The census also shows a marked decrease in the number of apple trees, and this is probably due to a considerable degree to the natural dying off of the old family orchards, which have not been replaced.

At present the agriculture consists of general farming combined with dairying. Poultry products are important on nearly all farms, though there are but few exclusively poultry farms. The chief cash crop is wheat; but in places rye and buckwheat are grown for sale. Hay, corn, and oats are the principal subsistence crops, and only the surplus of these is sold.

According to the census, the total area in cultivated grasses in Somerset and Morris Counties in 1919 was 40,183 acres, yielding 44,940 tons of hay.[2] Of this there were 18,485 acres in mixed timothy and clover, 14,346 acres in timothy alone, 2,149 acres in clover alone, and 2,840 acres in alfalfa. Only 256 acres of alfalfa were reported for the two counties in the 1910 census. Of the other tame grasses millet is of considerable importance. Due to the increasing number of automobiles and trucks in the cities, hay production for other than subsistence purposes is on the decline. The acreage of tame grasses is only about two-thirds as large as it was 10 years ago. Silage crops occupied 2,393 acres in 1919, and corn was cut for forage from 7,745 acres. This is a marked increase over the acreage of similar forage crops reported for 1909.

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[2] In giving crop statistics of this area the figures for Morris and Somerset Counties alone will be given. The total extent of these two counties is about the same as of the area surveyed, and the parts of these counties not included in the area surveyed are very similar to the included parts of Hunterdon, Middlesex, and Morris Counties. Parts of Middlesex and Morris Counties, however, are more thickly settled, and so the figures for the area surveyed, if they were obtainable, would be slightly different.

Corn for grain was grown on 25,145 acres in the two counties in 1919, with a production of 946,287 bushels. This does not include the acreage of corn cut for silage and for forage. Oats were grown on 16,077 acres, producing 327,041 bushels. Wheat was raised on 13,797 acres, yielding 220,757 bushels; rye on 8,115 acres, yielding 105,138 bushels; buckwheat on 2,009 acres, yielding 25,399 bushels.

Potatoes and other truck crops are of importance near the large towns on certain soils in Union and Middlesex Counties. Peaches, apples, and pears are important locally, and in a few places small-fruit production is of importance. Near New Providence, Summit, and Chatham there are a number of very large greenhouses devoted to growing flowers, mainly roses.

Dairying is the leading industry on a majority of the farms. According to the census there were 19,485 dairy cattle in the two counties on January 1, 1920, of which about 70 per cent are classed as milk cows. The value of the dairy products, exclusive of milk and cream used in the home, for 1919 was reported as $2,005,127. The greater part of the income from dairy products is derived from the sale of whole milk in neighboring cities.

Statistics concerning the number and value of animals sold or slaughtered in 1919 are not available. The value in 1909 was reported as $600,630. Hogs and calves made up the greater part of the animals sold or slaughtered. On many of the estate farms the raising of blooded horses, cattle, and hogs is important. Sheep are kept by a few farmers.

The poultry industry is of considerable importance. There were

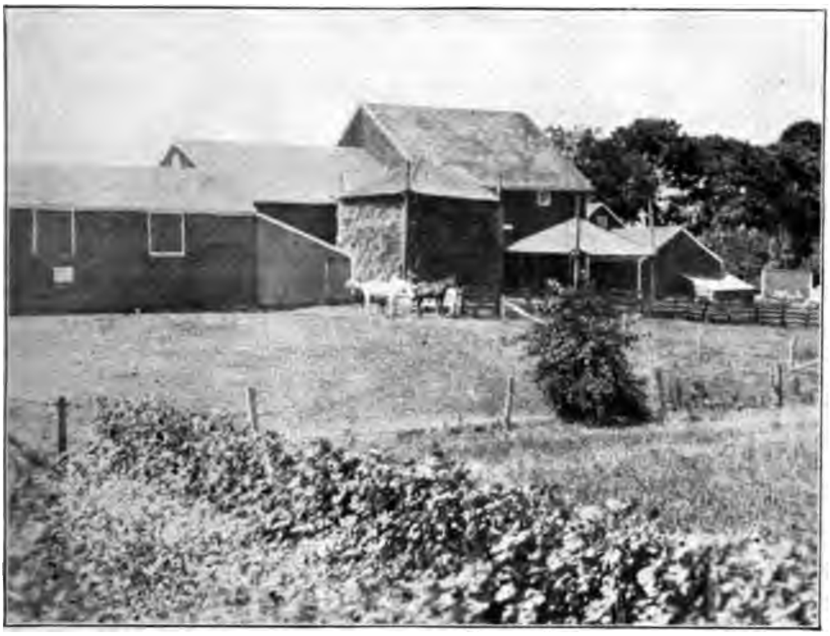

FIG. 1.—TYPICAL FARM BUILDINGS ON WASHINGTON LOAM, NORTHWEST OF SOMERVILLE.

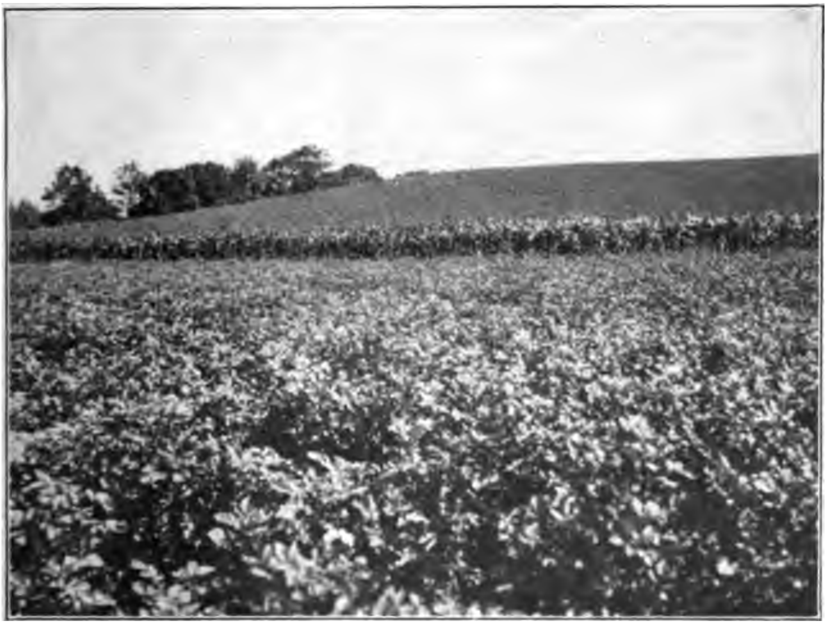

FIG. 2.—ROLLING TOPOGRAPHY OF THE MONTALTO GRAVELLY LOAM.

Alfalfa in foreground, corn in middle distance.

the Whippany, Watchung, Croton, and Roanoke soils. These soil adaptations to some extent govern the farm practices.

The farm buildings are well constructed, large, and numerous (Pl. XV, fig. 1). Since this section has been settled for hundreds of years, and each generation has added some improvements, it appears natural to find that a rather large proportion of the total farm value is in buildings. These constitute nearly 40 per cent of the entire farm value. The laws regarding milk production in the State are very strict and usually are rigidly enforced, and as a result the cow stalls, which are usually situated on the ground floor of the barn, are well lighted and are well kept. The upper parts of the barns are constructed to hold large quantities of unbaled hay and straw. Some hay and straw is stacked outside or put up in a peculiar form of shed called a "barracks." The roof of the barracks can be raised or lowered as the size of the stack increases or decreases. In addition to the barn and house, there are usually a number of smaller buildings, including sheds for farm machinery, garage, tool houses, chicken houses, hog houses, and silos.

The farm implements are numerous and constitute over 5 per cent of the entire farm value. Such modern farm machinery as threshers, shellers, feed grinders, gasoline engines, drills, manure spreaders, two-row corn planters, two-row cultivators, corn harvesters, reapers, and binders are found on most of the farms. In recent years, owing to the high cost and scarcity of efficient labor, tractors have become very popular. The smaller tractors appear to be more in demand than the larger types. Motor trucks are owned by many of the larger farmers and are used for hauling milk and other products to market. Work horses are large and are generally kept in sufficient number to do the necessary hauling and much or most of the plowing on nearly all of the farms.

The value of domestic animals constitutes nearly 10 per cent of the entire value of the farms in the two counties. The greater part of this value is in dairy cows, which number, as a rule, about 4 to 25 per farm. They are usually good grade animals, predominantly of Holstein blood. Purebred herds are kept by some of the large estate farmers.

Land is usually broken to an average depth of 6 inches with turning plows drawn by two, three, or four horses or by tractors. When tractors are used the land is broken deeper. After breaking the land the seed bed is prepared by the use of various kinds of drags, rollers, and harrows, depending upon the structure and nature of the land. When plowing is done in the fall usually the first implement used in the spring is the disk harrow. The two-horse drill is commonly used in seeding the small grains, and when commercial fertilizer is used it is applied with the seed. On some of the rougher, stonier lands the small grain is still sown by hand.

Corn is planted in several ways. Where the check-row system is used, three or four grains are put in a hill in rows 3 to 4 feet apart and so arranged that they can be tilled on all sides. In this case hand planters are used. The more common method is to use a corn planter and to drop the grains singly from 12 to 20 inches apart in rows 3 to 4 feet from each other. When the corn is to be used for ensilage it is usually planted closer together than when planted for grain. If it is to be fed green to stock during the growing season, it is usually sown by hand and is cut at a height of 2 or 3 feet. This crop is never cultivated, but corn for grain or ensilage receives several cultivations during the growing season. Corn is planted toward the end of May and cut early in October. After cutting it is shocked, allowed to dry, husked, and put in the crib. For ensilage the corn is cut when in the dough stage.

Wheat and rye are drilled about the middle of September. Timothy seed is sown with wheat or rye, and clover is broadcasted in the spring on the grain by the use of a wheelbarrow seeder. In years when the Hessian fly is feared, the farmers often do not drill their wheat until after a hard killing frost, thus causing a delay of two or three weeks beyond the usual seeding time. The grain is harvested in early July and stacked before threshing. Oats are seeded early in the spring and harvested in July or August. Buckwheat usually is sown where some other crop has failed, or on land which for some reason could not be planted to some other crop. It is sown any time before the middle of July.

The general farm crops are grown in rotation on nearly every farm. The common rotation consists of corn 1 year, oats 1 year, wheat or rye 1 year, and timothy and clover hay for 1, 2, or 3 years. There its use on the land was very common.[3] Many of the kilns are still standing, but they are no longer in use, and only a few of the farmers are using sufficient lime to obtain the best results.

Some cow feed is purchased during the winter months by nearly all dairymen. The expenditure for feed in Morris County in 1919 was $709,574 on 1,059 farms reporting, and in Somerset County for the same year, $565,054 on 1,143 farms.

The greater part of the farm labor is performed by the farmer and his family. Extra help is necessary during harvest seasons, and on the larger farms some farm hands are hired by the year. Before 1914 the labor question was rather troublesome, but laborers usually could be obtained, as there were a number of young men in most localities who were willing to do harvest work. They were mostly native whites. Since 1914 the problem has become very serious, and many fields have been abandoned by the farmers because of the high wages. Farm laborers receive $4 to $5 a day, or $50 to $75 a month and board, but enough can not be obtained even at these wages.[4]

The farms in the area range in size from a few to several hundred acres. The smaller farms are on the sandier soils in the eastern part of the area, where truck farming is carried on extensively, and the largest farms are owned by wealthy business men. These extremes are not typical. The average general farm contains about 100 acres. According to the 1920 census, there are 1,333 farms in Morris County with an average size of 92.7 acres, of which 53.9 acres or 58.1 per cent is improved. In Somerset County, where there is a smaller percentage of rough land, there are 1,454 farms, with an average size of 94.2 acres, of which 77.7 acres, or 82.5 per cent, is improved land.

About 73 per cent of the farms in Morris and Somerset Counties are operated by the owners. Two systems are used on the rented farms—cash rent and share. There are nearly as many different variations in the share system as there are rented farms, for in each case there is an agreement in which the details are specified. Often the owner furnishes the land, buildings, and permanent fixtures, pays for half the fertilizer and seed, and receives half the grain. When the owner furnishes the cows he receives a certain proportion of the milk receipts and calves.

Land values vary considerably, depending mainly on location with reference to good roads and towns, character and nature of land, and improvements. In country-estate farming sections the price of land is often exceedingly high. Near the commuting sections small tracts of land are called farms and sold to city people at very high prices.

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[3] Lime was burned not only in the sections where limestone was plentiful, but in many places the limestone was hauled to the farm or neighborhood where it was to be used, and then burned.

[4] These wages prevailed in 1919 when the field work was being done.

The general range is from $40 to $150 or $200 an acre. The average value of all farm property in Morris County, according to the 1920 census, is $15,284 per farm, of which 43.3 per cent is represented by the land. For Somerset County the average value of all farm property per farm is given as $15,145, of which 47.3 per cent is represented by the land.

SOILS.[5]

In the Bernardsville area there is a great variety of soils, owing to the fact that the area embraces parts of several well-recognized physiographic divisions, includes various rock formations, and represents several soil provinces of the United States. It includes some of the comparatively level country of the Coastal Plain, part of the Piedmont Plateau region, some Limestone valleys, Glacial drift areas, and a section of the Appalachian Mountains. The details of the profile or soil section vary greatly according to the parent material, and also to the topographic and drainage conditions.

Many of the soils in this area may be very broadly grouped as mature, well-drained soils which in their virgin state possess a profile having somewhat similar characteristics as regards color, number of horizons, texture and structure within the 3 or 4 foot section. This profile may be considered the standard for the climatic and vegetative province in which it occurs. It covers the forested region of the eastern part of the United States lying between southern New England and North Carolina, the boundaries, of course, being given in general terms.

The essential features of such a profile are as follows:

(1) Gray to dark-gray horizon, varying in thickness from a mere film to 2 inches. This includes the surface leaf mold and an admix-

) This horizon consists of slighty weathered parent material. texture of this depends upon the character of the original mate- If the parent material be heavy, this horizon is apt to be more tic and tougher than No. 3. It is usually mottled or character- by streaks and spots of brown, yellow, and gray, due to partial hering, and is usually encountered at less than 40 inches.

. cultivated fields horizons 1 and 2 have been thoroughly mixed— is, in the first few inches—and the color depends upon the state ltivation and methods of handling the soils.

e well-drained, mature soils of the Bernardsville area belong in group. They are the various types of the Sassafras, Gloucester, ter, Hagerstown, Merrimac, Washington, Lansdale, Dunellen, talto, and Penn series.

nother group of soils in the Bernardsville area consists of the soils loped under conditions of excessive moisture. They have always . waterlogged or poorly drained and their present character is due arily to that fact. They include the various members of the ppany, Clyde, Elkton, Papakating, and Wehadkee series. The ous soils consisting of recent deposits of alluvium, such as the soils e Podunk, Codorus, Bermudian, and Birdsboro, are immature, ng developed no profile of their own as soils. Their profiles con- of the various strata laid down at the time of their deposition. r profile is therefore a geological and not a soil profile.

e Croton soils are characterized by the heavy plastic subsoil the highly eluviated soil or surface horizon characteristic of . soils.

l of the soils of the Bernardsville area, except small areas of k, Clyde, and Papakating, are light in color; that is, they range gray to brown in the surface portion. The mature, well-drained are more uniformly brown in color. All the soils are being ected to leaching and all have been leached and are permanently leached of most of their readily soluble material. The concen- on of mineral matter in the soil water, so long as it depends on first, second, and third horizons only for its source of mineral rial, tends to become constantly more and more dilute, other s remaining equal. This leaching, together with better drainage ation, and other changes taking place in the soil, has a general ency toward a simplification of the soils rather than an increase heir complexity. In other words, these agencies are working rd a uniform soil section or profile.

ith the exception of the Muck and Clyde soils, the soils of the ardsville area are, for the most part, low in organic matter. is accounted for by reason of the area being well drained, and, l reclaimed for agricultural purposes, covered with forest. The small amount of organic matter, or vegetable mold, in the forested areas is only a superficial covering, and when the land is cleared and cultivated for a few years this is dissipated largely or is so thoroughly mixed with the soil that it does not appreciably influence the color of the surface soils.

There is no free deposit of carbonate of lime in any of the soils of the area, even where the original rocks contained lime, for with the heavy rainfall, leaching, and good drainage, this and other soluble materials have not accumulated as they normally would in the drier regions of the United States.

In classifying the soils of the Bernardsville area, there is found to exist a close relationship between the various soils and the geological formations from which they are derived.[9]

The principal rock formations of the area consist of gneiss, limestone, shale, sandstones and conglomerates, diabase and basalt, schist, slate, and argillite. The Watchung Mountains are underlain by basalt, while the Sourland Mountain and the ridge just west of Oldwick (New Germantown) have diabase beneath them. The crystalline rocks consist of gneiss, basalt, and diabase. Most of the soils of the area are underlain at varying depths by solid rock. The limestone and shale are of minor importance, while the Triassic sandstone, conglomerate, and argillite are the most important of the sedimentary rocks and underlie the Piedmont Plateau region.

It appears that two ice sheets invaded the northern and eastern parts of the Bernardsville area. The earliest of these, the Jerseyan, deposited a mantle of drift, but no terminal moraine is now apparent. In many places the drift has been entirely removed. Gravel, cobblestones, and bowlders are in evidence. The later, the Wisconsin, left material. In the series descriptions are given the source of soil material and processes by which the soils have been formed.

The glacial soils include all of the types mapped in the area that are derived from unstratified drift or till, including deposits of both the Jerseyan and Wisconsin ice sheets. These types are grouped into three soil series—Washington, Gloucester, and Wethersfield.

The types of the Washington series are characterized by brown surface soils and a reddish-yellow or light-red, moderately friable subsoil. Angular fragments and rounded gravel and cobblestones of gneiss, quartzite, chert, and other siliceous rocks are present in soil and subsoil. The parent material consists of old glacial drift remaining here and there south of the moraine of the later drift (Wisconsin), most of it occurring in the valleys and over the flatter areas underlain by gneiss. Some of it is found over the Triassic shale and sandstone and some over basalt and gneiss. Probably limestone was present in the material, but evidence of such material has been removed by decay and leaching.

The types of the Gloucester series have light-brown or grayish-brown surface soils and a yellow and yellowish-brown friable subsoil. They are derived from glacial drift which consists for the most part of material derived from gneiss and trap rock. Large quantities of grit are present throughout the soil and subsoil. The rounded rock fragments consist of gneiss, trap rock, quartzite, sandstone, and quartz. Huge bowlders are present in many places. The Gloucester loam, with two phases, is mapped in the area.

The types of the Wethersfield series are brown or chocolate brown in the surface soil and Indian red in the subsoil. They are derived from glacial till composed largely of material of shale and sandstone of Triassic age. The foreign material consists of trap rock, gneiss, and quartzite, gravel, cobblestones, and bowlders of these rocks being present in the soil and subsoil. These soils occur on typical morainic topography (very hummocky). The gravelly fine sandy loam and the gravelly loam types are mapped.

Glacial Lake and River Terrace soils embrace the soils that are derived from stratified glacial deposits, including those formed by streams and those formed in the beds and along the shores of old lakes. The Clyde and Whippany series and Muck are developed in the wetter parts of the old lake beds. They differ mainly in the content of organic matter. The Merrimac and Dunellen are well-drained soils of this group.

Muck consists of decomposed organic matter mixed with a small amount of mineral soil material. It is very swampy and wet.

The Clyde series consists of types with dark-brown or black surface soils and mottled gray and yellow clay subsoil, with gray or greenish-gray sand in places. These are poorly drained, swampy soils.

The Whippany series is characterized by the gray to light grayish brown color of the surface soils, the yellow or mottled gray and yellow color and generally plastic nature of the upper subsoils, and the presence of a tough, impervious clay pan in the lower subsoils, normally of a dull Indian red color, mottled in places with yellow or gray. These soils occupy flats into which materials from glacial uplands have been washed, and to some extent from the residual soils, such as the Penn and Chester. The greater part of this material appears to have accumulated in the low places formerly occupied by old glacial lakes. The drainage is very poor.

The types of the Merrimac series have brown to light-brown surface soils, with a friable, brownish-yellow subsoil and normally a lower stratum of yellow, brown, or reddish, more friable material. They owe their origin to the weathering of material placed by glacial waters or by the reworking of glacial material by streams. Most of the material has been derived from the regional crystalline rocks, consisting mostly of gray and white gneiss and dark fine-grained basalt. The soils have a flat to sloping topography and are well drained.

The types of the Dunellen series are characterized by the dark reddish-brown color of the surface soils, and by the lighter reddish-brown to Indian-red color and friable structure of the subsoil. The lower subsoil is almost invariably coarser textured, containing more medium and coarse sand and fine gravel than the upper subsoil. These soils are derived from a stratified glacial material of outwash plains lying south of the terminal moraine, or from stratified drift within the glaciated regions. Locally, some of the material is derived from unconsolidated material of the Coastal Plain region, but this has been included with these soils because most of the material is of Triassic

The Limestone Valley soils have been derived from the Kittatinny limestone. In the weathering of this limestone most of the bulk of the original rock is carried away in solution, leaving the impurities in the original rock to make up the main part of the soil. The bedrock is from 3 to 8 feet below the surface. The soils have been correlated with the Hagerstown series, which includes types with brown, mellow surface soils, and a brownish-red or brownish-yellow friable clay subsoil.

The soils of the Piedmont Plateau region include the Montalto, Watchung, Penn, Lansdale, and Croton series.

The Montalto soils are derived from the weathering of the basalt and diabase of the Watchung and Sourland Mountains. The surface soils are brown and the subsoil is reddish brown or reddish yellow.

The Watchung series consists of types having grayish-brown or gray surface soils and a pale-yellow or mottled gray and yellow subsoil, with a tough plastic clay-pan layer in the lower part. This layer is a dull-chocolate or brownish color, mottled with gray or bluish gray and yellow. The soils are derived from material coming from trap rocks and differ from the Montalto soils with which they are associated in being poorly drained.

The Penn series include Indian-red soils and Indian-red subsoils which have been derived from the underlying Indian-red shale, sandstones, and conglomerates of Triassic age. The shale loam, gravelly loam, and silt loam types are mapped.

The Lansdale series includes types with brown or grayish-brown surface soils and a yellow or yellowish-brown moderately friable subsoil. The material has been derived from the underlying gray shales and sandstone, or dark argillite of Triassic age. The shale loam, gravelly loam, and silt loam types are mapped.

The types of the Croton series have grayish to brownish-gray or ashy-gray soils, and a mottled yellow and gray clay upper subsoil, below which an impervious, heavy, compact hardpan layer, mottled yellow, brown, and bluish gray, is encountered. The characteristics of these soils are due to some development favoring the formation of a hardpan layer in the subsoil. They are formed of material derived from any or all of the sedimentary Triassic rocks, including especially argillite. The silt loam type alone is mapped in the present area.

The Coastal Plain soils of the Bernardsville area are derived from unconsolidated sandy clays, heavy clays, sands, and gravels. In addition to the true Coastal Plain part of the area in the southeast corner, the adjoining area underlain by the Triassic rocks is covered in places with deposits of similar material, and such areas have been included with the Coastal Plain region. Sassafras and Elkton series are represented.

The Sassafras series includes types with brown or grayish-brown surface soils and a reddish-yellow, reddish-brown, or orange-colored friable subsoil, which is typically coarser in texture and less compact in the lower part. Small whitish quartz gravel is found in many places on the surface or in the soil or subsoil, or from the surface down. The Sassafras loam, sandy loam, and sand are mapped.

The Elkton series is characterized by gray surface soils and a light-gray or mottled light-gray or bluish-gray and yellow subsoil. The material corresponds in origin with that of the Sassafras. Poor drainage as a result of the flat or depressed position has caused the grayish and mottled colors characteristic of the series.

River Flood Plain soils include the soils that have been transported and deposited by streams. These are of two classes: (1) Those occupying low-lying or first-bottom positions along the water courses, where they are subject to periodical overflow, and (2) the terrace or second-bottom soils, occupying benches which formerly were the first bottoms of the streams, but which now represent second or third bottoms, the stream channels having been cut deeper to form new and lower flood plains and to leave the old bottoms above overflow, or at least above ordinary overflow. On second bottoms were mapped the Birdsboro and Roanoke series, and on first bottoms the Papakating, Podunk, Codorus, Wehadkee, and Bermudian series.

The Birdsboro series includes brown to reddish-brown or dark reddish brown soils developed on alluvial deposits, representing reworked material coming mainly from the Penn soils. These are well-drained terrace soils occupying second and third bottoms.

The types of the Roanoke series are characterized by gray or mottled surface soils and a mottled gray or bluish-gray and yellow subciated mountain sections of the area, and represent wash chiefly from the Chester and Montalto soils. Mica flakes are present in both soil and subsoil.

The Wehadkee series consists of types with gray surface soils and a mottled gray or bluish-gray and yellow subsoil. In places the lower subsoil is a dull-reddish, tough, plastic, rather impervious clay. These soils are poorly drained.

The Bermudian series includes Indian-red to reddish-brown first-bottom soils composed largely of wash from the Penn soils. They are characteristically friable and are well drained between overflows.

In the chapters following the characteristics of the various types and phases are described more in detail, and their relation to agriculture is brought out.

The table below gives the actual and relative extent of the soils mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Chester loam	6,400	15.0	Clyde loam	6,848	1.5
Gravelly phase	37,184		Penn gravelly loam	6,784	1.5
Stony phase	25,984		Sassafras loam	6,720	1.4
Penn silt loam	66,432	14.3	Montalto silt loam	6,656	1.4
Gloucester loam	2,048	9.6	Croton silt loam	6,016	1.3
Stony phase	25,024		Podunk loam	5,376	1.1
Gravelly phase	17,856		Papakating silt loam	5,248	1.1
Penn shale loam	26,432	5.7	Merrimac fine sandy loam	4,352	.9
Whippany silty clay loam	22,144	4.8	Birdsboro silt loam	3,228	.7
Washington loam	13,184	4.4	Tidal marsh	2,880	.6
Gravelly phase	7,232		Watchung silty clay loam	2,624	.6
Bermudian silt loam	18,916	4.1	Lansdale shale loam	2,112	.4
Montalto stony loam	17,792	3.7	Lansdale gravelly loam	1,920	.4
Wethersfield gravelly loam	17,024	3.7	Lansdale silt loam	1,792	.4
Montalto gravelly loam	16,192	3.5	Roanoke silty clay loam	1,344	.3
Dunellen sandy loam	11,712	2.5	Papakating silty clay loam	1,280	.8
Dunellen loam	11,072	2.4	Wethersfield gravelly fine sandy loam	1,280	.3
Merrimac loam	3,584	2.4	Hagerstown silt loam	1,216	.3
Gravelly phase	7,424		Sassafras sandy loam	1,024	.2
Codorus loam	10,880	2.4	Elkton clay loam	832	.2
Merrimac sandy loam	6,208	2.3	Sassafras sand	512	.1
Gravelly phase	4,480		Wehadkee silty clay loam	512	.1
Muck	7,232	2.3	Clay pits	192	.1
Intermediate phase	1,856				
Shallow phase	1,216				
Rough stony land	7,744	1.7	Total	464,000	

WASHINGTON LOAM.

The Washington loam is a brown mellow loam grading at about 8 to 10 inches into yellowish-brown, friable silty clay loam, which passes into reddish-brown, friable silty clay containing in places sufficient Indian-red material in the lower part of the 3-foot profile to give a reddish cast. Both soil and the subsoil contain considerable grit. The texture of the type as mapped ranges in places to a silt loam. In a number of places areas of Washington silt loam are included. An attempt was made to separate the loam and silt loam, but it was found impracticable, owing to the fact that in so many places the grit is so noticeable that the soil does not have the texture of silt loam, even though much of the fine material consists of silt. On the mountains where it was mapped over the gneiss it is unquestionably a loam in texture, but where mapped over the red shales and in the valleys it is not everywhere a loam. Nearly everywhere there are present noticeable quantities of gravel and cobblestones of the same kind as found on the gravelly phase, described below. The thickness of the glacial material which gives rise to the Washington loam varies from about 18 or 20 inches to many feet. Much of the soil mapped over the red shale formation in the southwestern part of the area is, comparatively speaking, rather thin. In the areas mapped in the vicinity of White House and Readington, north of Somerville, and in several other places in this part of the area, the red shale soil material is encountered locally at depths varying from about 18 to 36 inches. In many of these places the lower subsoil appears to be made up largely of the red shale soil material (Penn), and in other places such material appears to have had a marked influence upon the lower subsoil.

The Washington loam occurs in large tracts in many places in the western half of the area, south of the moraine. Large and important bodies lie in the gneiss hills south of Mine Hill, at the lower end of Budd Lake, east of Dover, and north of Mendham. Other tracts occur in the valley in which Flanders and Bartley are situated, north-this fruit. Another cause of the decline has been the failure of some to adopt modern methods of orchard management.

Dairying is of first importance on most of the farms. The milk is sold to the city markets as whole milk. A few farmers have special customers in near-by towns whom they supply with butter, and there are a few cheese and butter factories in the area. A few horses and mules are raised, but most of the horses are purchased from western markets. Hogs and poultry products are of minor importance on most of the farms, though a larger revenue is obtained from chickens than is usually realized by most of the farmers. Fruit and vegetables of all kinds are produced, usually in sufficient quantities to supply the home.

Corn yields range from about 35 to 80 bushels per acre, averaging about 50 bushels. An increasing proportion of the crop is being put into silos for winter feeding. Oats yield from 35 to 45 or even 50 bushels per acre, and wheat yields about 18 to 25 bushels. Hay yields from 1 to 2 tons, averaging about 1½ tons per acre.

Crops are grown in rotation. Up to a few years ago a five-year rotation of corn, oats, wheat, or rye, followed by timothy and clover for two years, was the most common, but since the market for surplus hay in the cities has fallen off, owing to the increasing number of automobiles and trucks, many of the farmers consider it best to allow grass to occupy the land only one year. In this way they produce enough on most farms to feed their own stock, but have little surplus for sale. Good, thorough tillage methods are practiced generally. Two-horse and three-horse plows, cultivators, harrows, reapers and binders, and corn harvesters are used. The smaller tractors recently have become very popular. The stable manure made on the farm is applied to the sod as a rule before turning under for corn, and small grains are fertilized at seeding time with about 150 to 500 pounds of commercial fertilizer low in nitrogen and high in phosphoric acid. Wheat as a rule receives more fertilizer than oats. In order to obtain the best stands of clover, farmers say they have to use some form of lime, but many of them neglect to apply it.

The value of land of this type for farming formerly ranged between $50 and $125 an acre, depending upon the general condition of the soil, the improvements, and the location. In recent years of general inflation of land values it has been held at higher figures.

Washington loam, gravelly phase.[a]—The Washington loam, gravelly phase, consists of a brown gritty loam about 8 to 10 inches deep, overlying yellow gritty clay, which passes into a reddish-yellow, friable gritty clay. In many places the subsoil is reddish yellow even in the upper part. In a few places near the Penn soils the lower subsoil has an Indian-red color, showing that in such places this subsoil material is derived mainly from the underlying shales of Triassic age. On the surface and through the soil and subsoil there is an abundance of rounded gravel and cobblestones. These stones consists of gneiss, chert, quartzite, sandstone, and other hard rocks. Many of the chert fragments show holes representing former limestone fragments which by weathering processes have been completely dissolved and removed. Many of the gneiss fragments have disintegrated and it is probable that this material gives rise to the gritty particles commonly present in the lower subsoil.

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[a] This soil is really a distinct soil type—a gravelly loam—but in this area it is mapped as a gravelly phase of the Washington loam in order to reduce as far as practicable the number of colors on the soil map.

The Washington loam, gravelly phase, occurs largely on the flatter parts of the gneissic hills and mountains, where it is associated with the typical Washington loam and the Chester soils. The largest areas were mapped on Mine Hill, south of Dover, about a mile west of Ledgewood, near Franklin, south of Naughright, and near Flanders. It has a gently rolling to sloping topography and good drainage.

This soil is nearly all cleared and is used extensively for farming. It is handled in the same way as the typical Washington loam, and the yields usually are as good. The only agricultural difference is that the slightly steeper or more rolling topography of the phase and its higher content of gravel make it more difficult to till.

GLOUCESTER LOAM.

The surface soil of the Gloucester loam is a brown loam about 8 to 10 inches deep. The subsoil is a light-brown to yellowish-brown clay loam, which grades beneath into a yellow or brownish-yellow clay

Gloucester loam, stony phase.[9]—The Gloucester loam, stony phase, is a light-brown to brown gritty loam, about 3 to 6 inches deep, overlying yellowish-brown, gritty loam, which passes into yellow very gritty clay loam at an average depth of about 10 inches. The grit consists for the most part of gneiss particles, but is in part of feldspar. In places mica flakes are noticeable. In some areas the subsoil has a slightly reddish color, but this is not typical. There is an abundance of angular and partly rounded gravel, cobbles, and huge bowlders of gneiss through the soil and subsoil and over the surface, together with some fragments of trap rock, reddish sandstone, and quartzite. This phase differs from the gravelly phase of the Gloucester loam, mainly in the larger amount of large stone fragments, cobblestones, and bowlders present.

In some areas mapped south of Dover and elsewhere the soil differs in that it contains some material apparently derived from deposits of the old Jerseyan ice sheet; but these areas have been included with the Gloucester because of similarity in character of material.

This phase is an extensive soil in the northern and northwestern parts of the area. It has a characteristic morainic topography, varying from hummocky and gently sloping to very hilly and mountainous. It has a steeper and rougher surface than the Gloucester loam, gravelly phase. It occurs at elevations ranging from about 500 to over 1,000 feet above sea level. Drainage is good but not excessive.

Nearly all of the area of this phase is covered with oak, chestnut (blight-killed), hickory, birch, tulip poplar, ash, basswood, elm, and in places hemlock. Ferns are numerous in the densely wooded areas.

The principal use of this soil at present is for forestry and pasture. Areas from which the timber and stones have been removed sufficiently for cultivation have been classed with the gravelly phase. A considerable part of this land as it now stands is capable of being so cleared and would make fine fruit land. A large part of it, however, is giving better returns at present in forest than it would in cultivation, for the slopes are too steep in most places for successful cultivation and should not be cleared.

Gloucester loam, gravelly phase.[10]—The Gloucester loam, gravelly phase, is very similar to the Gloucester loam, stony phase, except that it contains fewer stones, and most of these have been removed and placed in piles in the fence corners and along the edges of fields. These are for the most part of gneiss. Regardless of the fact that large quantities of stone have been removed in most places, the content is still large. The surface soil differs from that of the stony phase in that the brown upper layer is deeper, being usually 6 to 10 inches deep. This is due to the fact that it has been cultivated and reworked into a deeper lower layer by the plowing in of vegetable matter, whereas the stony soil is not cultivated at all. A considerable part of the fine earth contains gritty material in such quantities that it seems upon superficial examination much like a sandy loam.

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[9] This soil is really a distinct soil type, the Gloucester stony loam, but in this area it is mapped as a stony phase of the Gloucester loam, in order to reduce as far as possible the number of colors on the soil map.

[10] This soil is really a distinct type, the Gloucester gravelly loam, but in this area it is mapped as a gravelly phase of the Gloucester loam, in order to reduce as far as practicable the number of colors on the soil map.

Some hummocks of sandy loam have been included in the mapping because of their small extent. The largest and most important areas of this sandy loam are near Budd Lake and about one-half mile south of Chatham. In the general vicinity of Summit and Short Hills (lying just outside the area on the east) there appears to be a larger proportion of sandstone and shale material mixed with this soil, and although it is not as red as the Wethersfield soils, it has here a decidedly reddish cast in the subsoil. There are included patches of Gloucester stony loam and Wethersfield gravelly sandy loam.

The Gloucester loam, gravelly phase, is associated with the Gloucester loam, stony phase. The largest tracts are mapped in extensive belts near Morristown, Chatham, Summit, Morris Plains, and Boonton, where it occurs mainly on the ridges and higher positions. It is well drained.

Most of this soil has been cleared of stones and timber and is capable of being cultivated. Part of it is used for corn, oats, wheat, rye, timothy, and clover. Near the smaller towns in the eastern part of the area it is used for tomatoes, potatoes, cabbage, and other some small patches of loamy sand and fine sand included with the type as mapped, as in the area about 1½ miles northeast of Westfield. The gravel consists of reddish sandstone and shale, together with some gneiss, trap rock, and quartzite. This soil appears to contain more material derived from trap rocks than does the Wethersfield gravelly loam.

The type is developed on a terminal moraine and has a rolling hummocky topography. It occurs chiefly in the vicinity of Summit. It is well drained.

Much of the type is covered with forest of oaks, hickory, and dead chestnut. It is not extensive, neither is it important in the agriculture of the area, since most of it is either being used as building sites or held for sale for that purpose. Where farmed it is used for the same crops as the Wethersfield gravelly loam, and the yields are about the same.

WETHERSFIELD GRAVELLY LOAM.

The Wethersfield gravelly loam is an Indian-red to dark reddish brown loam, about 6 to 10 inches deep, overlying Indian-red friable clay loam to clay, which becomes stiffer and of a deeper chocolate red color at depths of about 30 inches. In many places it contains much grit, particularly in the subsoil. It also contains large quantities of reddish sandstone gravel and cobblestones and shale fragments, and in most places some trap rock and gneiss gravel as well. In some locations, as in the area on the high ridge about 2 miles north of Westfield, there are many large bowlders of trap rock and gneiss. Such stony areas are shown on the map by stone symbols. At Mountainside, east of Plainfield, and elsewhere the tops and the lower slopes of the ridges consist of sandy loam and fine sandy loam, but these have been included with this type owing to their small acreage. In small local depressions the lower subsoil is mottled gray and yellow, but these areas are small and few in number.

The type has been mapped on the moraines along the eastern border of the area beginning just south of Summit and extending to Metuchen. It has a hummocky, ridgy, or rolling topography. Except in the small depressions it is well drained.

The greater part of this type has been cleared of the original hardwood forest and is either under cultivation or in use for building sites. The town of Westfield is located on it, as also are many smaller towns. Where farmed the usual farm crops of corn, oats, wheat, rye, and hay are grown. Truck or market-garden crops, such as tomatoes, cabbage, onions, and Irish potatoes, are grown to a considerable extent. Several large dairy farms are on the type. The yields of crops are good, and the fertilizer and tillage methods are similar to those practiced on the other well-drained loam soils of the area. Its value at the present time ranges from about $80 to $125 an acre in the strictly farming districts, but much of the land lying within the suburban zone of New York City is held at much higher prices.

CLYDE LOAM.

The Clyde loam consists of a dark-colored or black mucky loam to silty loam, underlain at depths varying from about 7 to 30 inches, usually at about 10 inches, by a gray, black, or mottled grayish and yellowish or brownish heavy silty clay, which becomes stiffer below. In places the lower subsoil is a gray or greenish-gray loamy sand or sand. This type, as mapped, contains many variations. In places the clay layer is not present, the black surface soil being underlain by gray or mottled gray and yellow sand or loamy sand. In other places the clay is so stiff that one can hardly bore into it, and often the sand layer is not reached within the 3-foot section. Some areas consist of dark-brown to black loam, underlain by mottled gray, yellow, and rusty-brown clay, which in places has a clay-pan layer of yellowish-brown and rusty-brown color containing some dark concretionary material at depths of about 2 feet. Some of the areas consist of brown, dark-gray, or light-gray silt loam in the surface, with mottled yellow and gray silty clay subsoil. An attempt was made to separate the lighter gray patches of soil from the typical, but it was found impossible to do so on the scale of map used. In a number of included areas the soil contains a great quantity of gneiss cobblestones and large bowlders.

The type is associated in occurrence with the glacial-till and glacial-outwash soils. Some of the areas are associated with the Washing-

WHIPPANY SILTY CLAY LOAM.

The typical Whippany silty clay loam consists of gray or brownish-gray to grayish-brown silty clay loam about 6 to 10 inches deep, overlying mottled yellow and gray or bluish-gray heavy, plastic clay, which passes at depths ranging from about 24 to 30 inches into a tough, dull Indian-red clay pan which is faintly mottled in places with blue and yellow. The clay pan is so tough and stiff that it is nearly impossible to bore into it more than an inch or two without pulling the auger out. It is usually dry even when the surface is saturated with water. The higher parts are not so poorly drained, and differ from the typical soil in consisting of a gray-brown or light-brown silt loam to a depth of about 8 inches, underlain by mottled yellow and gray silty clay which becomes stiffer with depth. The clay pan is reached at about the same depth as in the typical soil. In places, as north of Hanover Neck and south of Whippany, this variation is located on high, flat areas or on poorly drained hillsides. In some included areas the lower subsoil is sandy, but these areas are very small and lie near areas of Merrimac sandy loam or fine sandy loam. Northeast of Stelton and at Clyde station the areas mapped as Whippany silty clay loam consist of material derived from deposits of the Coastal Plain. These have the same general characteristics as the typical soil, except that the surface soil is a silt loam. Here some Pensauken gravel is seen. In other sections some trap rock, gneiss, sandstone, and even shale gravel and cobblestones are not uncommon.

The Whippany silty clay loam typically is a glacial-lake soil and has been mapped in the poorly drained parts of the old Glacial Lake Passaic in the northeastern quarter of the area, as well as in poorly drained places in the southeastern part, where either old lakes or large glacial streams once existed. The largest areas were mapped south and east of the reservoir near Boonton, near Hanover Neck, Hanover, Whippany, Chatham, Madison, in the Great Swamp near Pleasant Plains, south of Stirling along the flats bordering the bottoms of the Passaic River, and in smaller bodies in this same general region. It is a low-lying swampy soil, much of it being under water during parts of the year. Some better-drained areas occur on higher elevations along the sides of hills or even mountains, but all areas are everywhere poorly drained.

The type is covered for the most part with pin oak, elm, hickory, maple, birch, alder, and hazel. In many open places a marsh type of vegetation is found. The cleared areas are used chiefly for pasture. In places where the drainage is naturally better or where it has been improved artificially, corn, hay, and truck crops, such as cabbage and tomatoes, are produced. In most cases these crops did not appear, at the time of the survey, to be thriving.

Land of this type in or near the suburban districts of New York is held at rather high prices; elsewhere it is a soil of moderate value.

The table below gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type:

Mechanical analyses of Whippany silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
170943	Soil	0.0	0.0	0.8	1.3	5.5	61.4	[1]31.0
170944	Subsurface	.0	2.2	1.0	2.6	4.1	62.8	27.1
170944½	Subsoil	.0	.0	1.2	1.8	2.8	65.0	29.0

[1] The material stated as "clay" is probably in part organic matter.

MERRIMAC SANDY LOAM.

The Merrimac sandy loam consists of brown sandy loam, underlain at about 8 to 12 inches by yellow or yellowish-brown sandy loam, which becomes lighter in texture below, grading in places into yellowish-brown light loamy sand or sand at about 30 inches. The subsoil has a reddish cast in some areas. In places small areas of sand, loamy sand, and coarse loamy sand are included with the type. Some areas included contain so much gravel that they really constitute a gravelly phase of the type, but some of these are not large enough to be shown on the map by the use of the gravel symbol. Near Green Village and in a few other places in the same general locality the areas mapped as sandy loam contain a number of small depressions of Muck, Clyde loam, and Whippany silt loam.

The Merrimac sandy loam is developed on stratified wash from e yields of the general farm crops, as well as of vegetables, are good. The fertilization and tillage methods are the same as e described in the chapter on agriculture. The truck crops are ilized more highly than the general farm crops. Many of the kers or market gardeners apply about 8 tons of stable manure acre. When commercial fertilizers are used, these crops receive to 600 pounds per acre. Many use both manure and fertilizer. hout manure and fertilizer heavy yields are not expected.

he value of this land is difficult to estimate, for much of it is er located near rather large industrial towns or in the commut- sections, and as a result the land often brings a very high price. laces it can be purchased at $75 to $125 an acre.

he productiveness of this soil would be improved by growing and asionally plowing under such humus-supplying crops as rye, vetch, l crimson clover.

Merrimac sandy loam, gravelly phase.[11]—The Merrimac sandy loam, avelly phase, is brown sandy loam passing beneath into yellowish- rown or light-brown sandy loam with sandy strata below, which re encountered in places within the 3-foot section. Both soil and subsoil contain waterworn gravel, consisting for the most part of gneiss and trap rock, along with some sandstone, quartz, and quartz- ite. Some of the sandstone is Indian-red and of Triassic origin, and in places small areas of Dunellen gravelly sandy loam have been included. There are also some included areas of sand. In places the subsoil is slightly reddish.

The phase is associated with the typical Merrimac sandy loam, but much of it occurs on higher knobs, ridges, or hills. It is well drained. In places where the gravel deposits are exceptionally deep, crops sometimes suffer in dry seasons from lack of moisture.

The phase is practically all cleared and is used in the same way as the Merrimac sandy loam. Some very fine orchards are established on it. It seems to be better suited to fruit, especially peaches, than the typical sandy loam, probably because it occupies a higher position and has better air drainage and greater freedom from unseasonable frosts. There is otherwise very little difference in the value of the typical soil and the gravelly phase for farming purposes. City residents, who often purchase tracts of these soils, seem to prefer the more hilly land, and for this reason the gravelly land often brings higher prices than that gravel free.

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[11] The soil is really a distinct soil type, the Merrimac gravelly sandy loam, but in this area it is mapped as a gravelly phase of the Merrimac sandy loam, in order to reduce as far as practicable the number of colors on the soil map.

MERRIMAC FINE SANDY LOAM.

The Merrimac fine sandy loam consists of brown fine sandy loam, rather heavy in places, about 8 to 12 inches deep, overlying light-brown or yellowish-brown fine sandy loam, which grades in the lower subsoil into coarse material, such as sandy loam, loamy sand, or a mixture of coarse sand and gravel. There is a reddish cast in the subsoil of some areas. In places, as at Berkeley Heights, this type caps hills of red shale, and here the lower subsoil in places contains fragments of red shale and is undoubtedly residual in origin.

About 1½ miles south of Morristown, on the other side of the trap mountain ridge, an area of Montalto fine sandy loam has been included with this type because of its small extent. This included area consists of a brown fine sandy loam, about 10 inches deep, overlying reddish-brown fine sandy loam, which passes at about 30 inches into a redder loamy fine sand. Some small angular fragments of basalt are on the surface and in the soil section.

The Merrimac fine sandy loam is found in the old lake regions and along the streams that deposited outwash from the glacial till. Important areas were mapped southeast of Morristown, in the northeast corner of the area, and in other places. Important developments of the type occur along the shores of old Lake Passaic, many of them on high benches or even on steep slopes along the sides of mountains, as, for example, the areas north of New Providence. In places the type occurs on the tops of small knobs and hills. The topography as a whole varies from rather steep to nearly level.

Most of the Merrimac fine sandy loam has been cleared of hardwood forest and is under cultivation. Both the general farm crops and market-garden crops are grown. In many places, as at Berkeley much grit. In nearly all places the extreme lower subsoil is more sandy and friable than the upper subsoil and it varies from yellowish-brown sandy loam to coarse sand, with a reddish cast here and there. Some gravel, consisting for the most part of gneiss, is present in many places. The area mapped south of Wharton is a silt loam, and represents an inclusion, not separated on account of the small extent of that type.

The Merrimac loam occurs in the same general region as the other Merrimac soils, and has a rather small total area. Some of the more important areas are on the terraces along the Rockaway River east of Silver Lake, southeast of Morristown, southwest of New Providence, and near Hanover Neck. Typically, it occurs on flat terraces. It is well drained.

Most of this type is cleared and farmed, being used chiefly for the production of the general farm crops. It is not as difficult to plow or cultivate as its gravelly phase, and has a slightly higher value as farm land. Generally the cultivation is efficient, good rotations are practiced, and some fertilizer is used. Rather liberal additions either of manure or fertilizers are essential for the production of good crops. The growing of legumes, such as soy beans and clover, may be expected to improve the soil, especially when a crop is plowed under occasionally.

Merrimac loam, gravelly phase.[12]—The Merrimac loam, gravelly phase (or Merrimac gravelly loam), is a brown gritty loam passing into a subsoil of similar color and texture and then into light-brown gritty loam, with yellowish-brown gritty clay, sandy clay, or clay loam below depths of about 2 feet. The lower subsoil in many places is an orange-colored sandy loam, coarse sandy loam, loamy sand, or coarse loamy sand. In places the subsoil is reddish. The surface soil varies in depth from about 6 to 10 inches. Scattered over the surface and through the soil section are large quantities of gravel and cobblestones of gneiss, with some of trap rock, quartzite, sandstone, and other rocks.

The Merrimac loam, gravelly phase, occurs in the same general regions as the other Merrimac soils, mainly along the streams which flow either through the glacial-till sections or out of these sections. In the latter case the phase has been mapped on the outwash plains south and west of the moraine. Large, important areas were mapped near Budd Lake, Ledgewood, and here and there along the Rockaway, Passaic, and Whippany Rivers. The largest body lies near Morris Plains. As a rule the topography is nearly flat, though some areas occupy small hills and knolls. The drainage is adequate.

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[12] This soil is really a distinct soil type, the Merrimac gravelly loam, but in this area it is mapped as a gravelly phase of the Merrimac loam in order to reduce as far as practicable the number of colors on the soil map.

Irish potatoes, tomatoes, beans, peas, cabbage, beets, asparagus, and other truck crops are grown on land of this type. In places wheat, oats, rye, buckwheat, corn, and timothy and clover hay are important. The yields, methods of handling, and fertilization are very similar to those on the Merrimac sandy loam. However, many of the farmers on this type do not manage their farms as carefully as those in most of the better farming sections in the area.

Most of the land is being cut up into building lots and is held at high prices, and many of the small tracts now farmed are rented, pending their sale as building sites.

The table below gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type:

Mechanical analyses of Dunellen sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
170931	Soil	2.8	15.8	14.4	29.9	10.7	19.1	7.2
170932	Subsurface	4.7	17.1	15.2	32.1	7.5	14.9	8.5
170933	Subsoil	4.0	19.8	16.7	38.8	7.9	6.4	6.4

DUNELLEN LOAM.

The surface soil of the Dunellen loam is a brown loam with an average depth of 8 or 10 inches. The subsoil is a dark reddish brown loam which grades at depths ranging from about 15 to 22 inches into Indian-red or dark reddish brown friable clay, and this usually passes into sandy loam, coarse sandy loam, or other material more friable than the upper subsoil, at depths of about 30 inches. In places the subsoil has a more yellowish brown color, with only a slight reddish cast, the color becoming more reddish below. Considerable small rounded gravel, consisting mainly of red sandstone, though some of it is composed of gneiss and trap rocks, is found in places on the surface and through the 3-foot section. Where the gravel occurs in abundance it has been shown on the soil map by gravel symbols. In places, as in the area about 2 miles south of Plainfield, the soil at the immediate surface consists of dark reddish brown loam and below this at about 10 inches of reddish-brown loam, this grading into Indian-red sandy clay at about 30 inches. In a few places, in positions somewhat lower than common, the subsoil shows some yellow mottling. Here the soil represents a gradation between the Whippany and the Dunellen loam.

Included with this type, as mapped, are some areas derived from deposits of the Coastal Plain region. Important areas of this variation are mapped south of Stelton and in the vicinity of Clyde. This material is a dark reddish brown loam, 8 to 10 inches deep, overlying friable Indian-red clay. Some rounded quartz gravel is present from the surface down. This gravel comes from the Pensauken formation.

The Dunellen loam occurs in broad belts in the general vicinity of Plainfield, Scotch Plains, Metuchen, Bound Brook, and Somerville. Other smaller areas are located south of Westfield, near Clyde, Stelton, and Mountainside, and in other places in the southeastern and east-central parts of the Bernardsville area. Its topography is flat to gently rolling, and its elevation ranges from 100 to 250 feet above sea level. As a whole it is a well-drained, productive soil.

The type has nearly all been cleared. Like the sandy loam soil of the same series, it is not an important soil in the agriculture of the area, owing to the fact that it is held for the most part as building sites, and much of it has been cut up into town lots. However, some of it is farmed, corn, oats, wheat, rye, buckwheat, Irish potatoes, and hay being the chief crops. Vegetable production is important in and near Plainfield and in some other places. The general farm crops are usually grown in rotation, the common succession being corn, oats, wheat (or rye), and grass for hay. The yields on the better farms are very good, comparing favorably with those obtained on the Penn silt loam.

The stable manure made on the farm is usually applied to sod land just before plowing for corn, and the oats and the wheat are fertilized with commercial fertilizer, usually a complete mixture. Wheat receives about 200 to 400 pounds of fertilizer per acre, and oats less.

The value of most of this soil is far in excess of its agricultural worth, owing to its favorable situation for suburban residences.

CHESTER LOAM.

he Chester loam consists of a brown to light-brown, friable, ty loam, 8 to 12 inches deep, overlying a yellow, friable, gritty subsoil. In places the subsoil has a reddish cast, but this is typical. The grit is derived from gneiss fragments, which are ent in all stages of decay. Mica flakes and white feldspathic icles also occur here and there. Two narrow patches just west he Chester station at the foot of a slope, included with this soil he map, consist of a brown sandy loam with a yellowish-brown ly clay subsoil. Near areas of the swampy Clyde soils, and in a other low places, the lower subsoil is pale yellow in color and e compact than typical. The parent rock is generally several below the surface, but lies within the 3-foot section in a few es.

he Chester loam occurs in the west-central part of the area. ortant tracts are mapped near Chester and Mendham, and veen Calais and Ironia. The type has a gently rolling topography, h flatter than that of the stony and gravelly phases. Usually ccupies the flatter tops of hills rising to an elevation of about feet above sea level. Except in local depressions, the type is drained.

he Chester loam is a strong, productive soil and is nearly all red of the original timber growth. The same crops are grown as he more extensive gravelly phase described below, and the yields, hods of handling, and the system of fertilization used are like- very similar. The loam is a little easier to handle, owing to smaller content of stone and gravel and to the smoother topog- ıy. As a consequence, the value is usually slightly higher than imilarly located areas of the gravelly phase.

hester loam, stony phase.[13]—The Chester loam, stony phase, is a wn to light-brown gritty loam, 2 or 3 inches deep, passing into owish-brown or yellow gritty loam, which grades below into gritty ow clay loam or clay. It is largely in forest, a fact which explains shallowness of the brown surface layer, which under cultivation eepened by plowing. It differs from the Chester loam, gravelly se (or Chester gravelly loam), in having an abundance of large fragments over the surface and through the soil and subsoil, in being more steeply sloping. Some of it has been cleared, the er stones removed, and the land put into cultivation. Much of area mapped as the gravelly phase originally consisted of this ıy phase.

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[13] This soil is really a distinct soil type, the Chester stony loam, but in this area it is mapped as a stony of the Chester loam, in order to reduce as far as practicable the number of colors on the soil map.

The Chester loam, stony phase, occurs in the west-central part of the area. It is developed on the steeper slopes, and as a rule has a much steeper topography than the typical Chester loam and the gravelly phase of the Chester loam. It is well drained and in places subject to erosion, though the many large stones tend to prevent excessive washing.

The soil is not important in the agriculture of the area, owing to its unfavorable topography and stoniness. Chestnut was an important tree on this soil, but nearly all the trees have been killed by the blight. Oaks, hickory, maple, basswood, and ash are among the species flourishing at present.

The chief value of this soil is for forestry and pasture, at least under present economic conditions. Much of it could be cleared of the stones and made suitable for cultivation, but it is believed forestry is the best use to which most of the land can be put. The cleared areas will be adapted to the same crops as the gravelly phase of the Chester loam, but in general they will be more difficult to farm, as the slopes are for the most part steeper.

The value of this stony land in many places near the large "estate" farms is too high for consideration for farming. In other places it is held chiefly for value of the timber.

Chester loam, gravelly phase.[14]—The Chester loam, gravelly phase (or Chester gravelly loam), is a light-brown or brown gritty loam, about 8 to 10 inches deep, overlying brownish-yellow or yellow friable gritty clay. Angular fragments of gneiss are abundant over the surface and through the soil and subsoil, giving a decidedly gravelly character to the land. Usually it is impossible to bore more than about 15 inches into this soil with the soil auger on occurrence with the typical Chester loam and the Chester loam, stony phase. All of these Chester soils occur in the west-central part of the area.

The topography varies from gently rolling to rolling. The phase occupies high hills, ridges, and hill slopes, at elevations ranging from less than 300 to over 1,000 feet above sea level.

The drainage is good. The gravel helps to keep the soil porous and to make it absorptive of moisture, and at the same time serves to retard erosion.

This soil is of great importance both because of its extent and of its agricultural value. It is nearly all under cultivation. The original forest growth was similar to that on the stony phase of the type.

The chief crops are corn, oats, wheat, and hay (timothy, redtop, and red clover). In addition, rye and buckwheat are grown extensively. Alfalfa is grown on many of the more nearly level areas near Chester and Mendham. Some fields with a very good stand of sweet clover were seen during the progress of the survey. A few years ago this soil was used extensively for peaches. At present this industry is less important, but there are still many large well-cared-for orchards. The little village of Oldwick is in the center of an important orchard district.

Dairying is practiced on nearly every farm. Practically all the milk is hauled to railroad receiving stations, where it is bottled, iced, and shipped to the larger markets for distribution. On a few farms situated several miles from a railroad some butter is made. The Holstein blood predominates in the majority of the dairy herds.

Hogs are raised in sufficient numbers to supply the home with pork, and only the surplus is sold. Chester White is the most common breed of hogs. Many of the "estate" farms make a business of raising purebred horses, cattle, hogs, and chickens. Poultry products form a large source of the income on most of the farms. Sheep are kept on some, but the fear of loss as a result of depredations by dogs tends to prevent an increase in the number of flocks.

Wheat yields range from about 15 to 25 bushels per acre, averaging about 18 bushels; corn averages about 40 bushels; oats, 25 to 30 bushels; timothy and red clover, from 1 to 1½ tons; and alfalfa, in several cuttings, about 5 tons per acre.

The main crops are grown in rotation. The most common scheme of crop succession is a five-year rotation, as follows; Corn, oats, and wheat (or rye), followed by timothy and red clover for two years. The timothy seed is sown in the fall, and the red clover is broadcasted over this with a wheelbarrow broadcaster in the spring. Alfalfa is sown either with wheat or rye late in August or with oats early in the spring. Very few inoculate for alfalfa, which probably accounts for reported failures to get a satisfactory stand on land that has not grown the crop before. Alfalfa is usually allowed to occupy the land for four or five years before it is displaced by another crop.

Reapers and binders, mowers, manure spreaders, two-horse turning plows, three-horse or four-horse sulky plows, drills, and many different types of harrows are found on nearly every farm. An increasing number of farmers are building silos and purchasing small tractors, hay loaders, corn cutters, and reapers and binders.

Both stable manure and commercial fertilizers are used on land of this type. The prevailing practice is to put all the stable manure on the sod before plowing for corn. The small grains receive from 200 to 500 pounds per acre of fertilizer, applied with the drill at time of seeding. Wheat usually receives slightly more than the other grains. The prevailing brand used before the European war caused a shortage of potash was a 2-8-10 mixture. Fish-scrap fertilizers are frequently employed.

The price of this land in many places greatly exceeds its agricultural value, owing to the demand for it for summer or country homes by city people who give greater consideration to location and landscape features than they do to agricultural value. Consequently the land in this region is held at $250 to $1,000 an acre. In other places the soil can be bought for $50 to $100 an acre, depending upon nearness to market, good roads, topography, state of fertility, and improvements.

The Chester loam, gravelly phase, needs lime and deeper and more thorough tillage.

HAGERSTOWN SILT LOAM.

The surface soil of the Hagerstown silt loam is a brown mellow silt

Areas of the type occur near Peapack, Gladstone, and Pottersville, and southwest of Ralston. It has a gently sloping topography and is everywhere well drained.

The Hagerstown silt loam is of small extent and, therefore, of little importance in the agriculture of the Bernardsville area, notwithstanding its productiveness. It is all cleared and under cultivation, and considered one of the strongest and best soils in the area for the general farm crops. A large proportion of it is seeded to alfalfa. Crop yields in general are somewhat higher than those obtained on the neighboring Chester soils. The soil is easily handled and well adapted to the use of all modern farm machinery. It is fertilized the same as the Chester soils. Dairying is relatively important on the Hagerstown areas.

This type has a higher value for farming than the associated soils, but since there are very few farms, if any, that are situated wholly on it, no accurate statement of its selling value can be made.

MONTALTO STONY LOAM.

The fine-earth surface soil of the Montalto stony loam is a brown silt loam about 6 to 8 inches deep. The subsoil typically is a brownish-yellow silty clay to clay, which grades below into reddish yellow moderately friable to rather stiff clay, but in places is reddish yellow or dull red. It is not so stiff as the red clay subsoil of the Cecil soils of the Piedmont region of the south. Mixed with the finer material is an abundance of stone, consisting almost wholly of basalt. The only important exception to this is the body mapped in the southwest corner of the area, just south of Neshanic, where the stone consists of diabase.

The type occurs with the other members of the Montalto series on the Watchung and Sourland Mountains. It occupies, as a rule, the upper and steeper slopes and is well drained.

Nearly all of it is in forest, mainly hickory, maple, dogwood, basswood, chestnut oak, and in a few places cedar. About the only use made of the soil, aside from forestry, is for pasture. Much of it, however, owing to its steep topography, should always be kept in forest; a part of it could be converted into tillable land by removing the larger stones. Some land that has been improved in this way is mapped as the gravelly loam of the series.

MONTALTO GRAVELLY LOAM.

The Montalto gravelly loam consists of about 6 to 8 inches of brown silt loam, underlain by a [illegible]-brown, [illegible] yellow, or reddish yellow to yellowish-red moderately friable silty clay. The material is very gravelly from the surface down, the gravel consisting of [illegible] grained basalt. In places gravel constitutes fully 50 per cent of the soil mass. The area mapped west of Oldwick and a few small patches mapped elsewhere are derived from a course-grained diabase, contain considerable gritty material, and are known locally as "mountain grit land." In some places there are still a few very large fragments of the parent rock in the fields. This soil has been derived from the underlying trap rock, except in those areas mapped at the foot of the steep slopes, where much of the material is of colluvial origin.

The largest areas of this type are those on the Watchung Mountains and on a hill just west of Oldwick. The topography is not as steep as that of the Montalto stony loam, nor is it as gently sloping as that of the Montalto silt loam. On top of the hills it is rolling to gently rolling. As a whole the drainage is good, but there are a few spots near areas of the Watchung silty clay loam where the drainage is imperfect.

The type is an important soil in the agriculture of the area, and at some time it has nearly all been cleared and farmed. In some sections many of the old farms have been allowed to revert to forest, but much of the land is at present farmed. The main crops are corn, oats, wheat, rye, buckwheat, and hay. There are many large peach orchards on the type, but the peach industry here is not as important as formerly. Before the development of the large peach districts in southern New Jersey this was one of the largest peach-growing sections in the country. Apples, pears, plums, and small fruits all do well, and are grown to a considerable extent. Alfalfa, though a minor crop, is increasing in importance (Pl. XV, fig. 2). Dairying is important. Poultry is raised on most farms, and there are a number that make poultry a specialty. South of Far Hills, near Basking

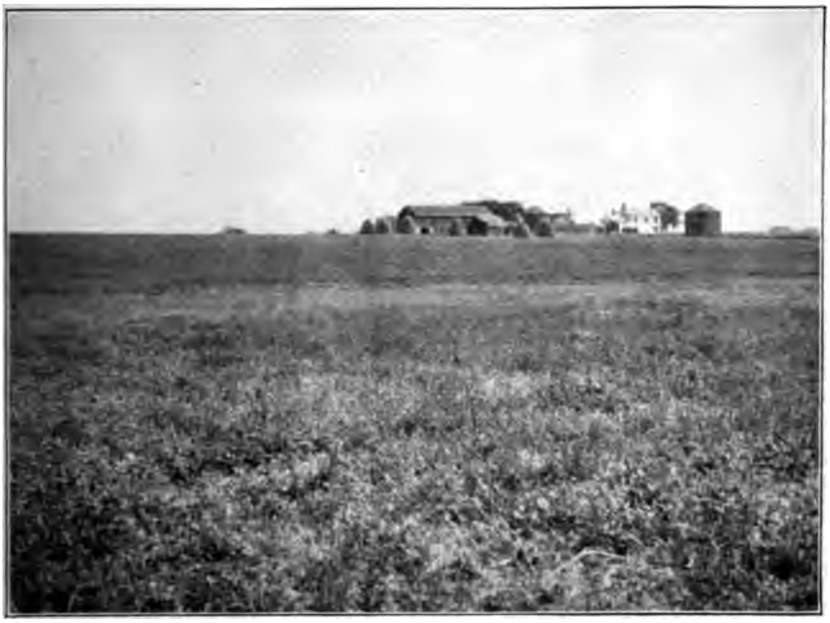

FIG. 1.—FLAT TOPOGRAPHY OF THE PENN SILT LOAM.

Timothy and clover in foreground, and typical farm buildings, with hay and grain stacks, in background.

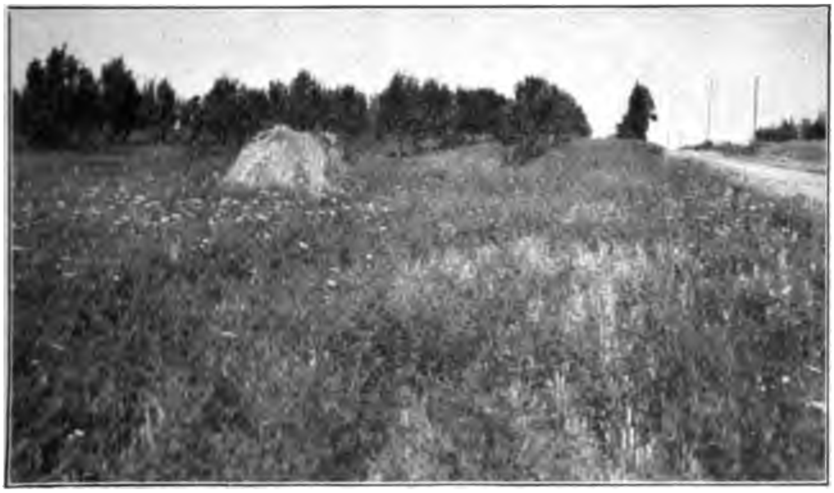

FIG. 2.—PEAR ORCHARD AND HAY FIELD ON PENN SILT LOAM.

MONTALTO SILT LOAM.

'he Montalto silt loam is a light-brown or brown to light reddish wn silt loam, grading at depths ranging from 6 to 12 inches into dish-yellow or reddish-brown silty clay loam, which passes into ible yellowish-red clay. In a few places, especially where the soil been derived from diabase, as south of Neshanic and west of Old-k, the soil contains more or less gritty particles of partly disinte-ted rock. There are some small fragments of trap rock in many ces, particularly near areas of the Montalto gravelly loam and ny loam types. At the foot of the hills where this soil has been pped it is largely of colluvial origin, and grades into the Penn soils ther down the slope. In such places the underlying rock is red le and the surface soil locally is a loam instead of a silt loam.

The type, which is associated with the other Montalto soils, occurs gently sloping or gently rolling to nearly flat areas. The drain- is good, except near areas of the Watchung soils, where in places underdrainage is poor.

The Montalto silt loam is rather an important soil in the area. It been cleared and is used chiefly for growing the general farm ps. It is handled in about the same way as the Montalto gravelly m. It is easier to cultivate and better suited to the use of proved farm machinery than the latter type.

The following table gives the results of mechanical analyses of nples of the soil and subsoil of the type:

Mechanical analyses of Montalto silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
9............	Soil.........	1.1	3.9	1.8	7.4	24.7	49.4	11.8
0............	Subsoil......	1.5	5.8	3.0	10.6	23.5	40.5	15.2

WATCHUNG SILTY CLAY LOAM.

The Watchung silty clay loam is a gray to brownish-gray silty clay m, 6 to 10 inches deep, passing into mottled yellow and gray stic silty clay loam or clay, which usually becomes tougher and re plastic with depth. In places the lower layer consists of an pervious plastic clay or clay pan, mottled with light gray or bluish-y and yellow. In other places, as in the area 1½ miles south of rling, this lower stratum is a dull Indian-red, plastic, tough clay clay pan showing some gray mottlings and containing fragments trap rock. Locally the surface soil is a shallow, light-brown silt am, and the subsoil is a yellow clay which passes in[illegible]t clay ntaining some brownish concretionary material. [illegible]ion is better drained and as a rule lies between the better-drained Montalto soils and the more typical Watchung areas.

The type occurs in numerous places on the ridges of Watchung Mountain and on the top of Sourland Mountain, mainly in small patches on the seepy, poorly drained slopes and in depressions about the heads of drainage ways. The whole type is poorly drained to swampy.

The Watchung silty clay loam is of little agricultural importance, owing to its small area and poor drainage. Most of it has been cleared of the birch, maple, cedar, and oak with which it was originally covered, and is used for pasture. Many of the smaller areas are devoted to the general farm crops, and where the drainage is sufficiently improved fairly good yields are obtained. In general the soil is badly in need of lime.

PENN GRAVELLY LOAM.

The Penn gravelly loam consists of Indian-red silt loam to loam, underlain by brighter Indian-red, moderately stiff or brittle clay. In many places the material below depths of 10 to 20 inches is Indian-red silty clay. Angular fragments and small cobblestones of whitish, grayish, and reddish quartz and quartzite are abundant on the surface and through the soil mass. In many places the gravel content is so large that it is impossible to bore many inches into the soil. The bedrock, a conglomerate composed of quartzite, quartz, and some limestone pebbles in a red matrix, is encountered within the 3-foot section in places. About a mile north of Whitehouse there is an area in which gravel, similar to that occurring in the Washington loam, gravelly phase, is thickly strewn over the surface. Here the original and hay. Dairying is carried on in conjunction with the growing of general farm crops. The whole milk is sold and shipped to New York and other city markets. Some alfalfa and sweet clover are grown.

Corn ordinarily yields 35 to 40 bushels per acre; oats, 20 to 40 bushels; wheat, 12 to 20 bushels; and timothy and clover hay, about 1 ton. Peaches, apples, and pears all seem to thrive where they receive proper care. The type is rather difficult to plow and cultivate, owing to the presence of large quantities of stone.

A large proportion of the Penn gravelly loam lies close to those sections where well-kept country estates tend to increase the price of land. The price in these sections is often several hundred dollars an acre. In other places this soil can be purchased for $40 to $100 an acre, depending upon location, topography, and improvements.

This is a good soil especially well suited to the production of fruits. Sweet clover grows along all the highways, and can be established in fields with very little trouble. It gives large yields of forage, and improves the soil. When cattle have acquired a taste for this hay, they seem to do very well on it.

PENN SHALE LOAM.

The Penn shale loam is an Indian-red silt loam, underlain at about 8 to 14 inches by a bright Indian-red clay, both high in content of red shale fragments. The subsoil in nearly all places rests on the parent shale rock within the 3-foot section. In places the lower subsoil is very friable as the result of the presence of partly decomposed shale material. The shale fragments vary in size from very thin plates to pieces an inch or more in thickness.

The Penn shale loam is extensive in the southern half of the area, particularly in the southwestern part. The largest bodies are those near Neshanic, Centreville, South Branch, Liberty Corner, North Branch, Readington, South Plainfield, Bedminster, Lamington, and Stirling. The largest and most important areas occur on the steeper slopes of the Raritan (both branches), Dead, Passaic, and Lamington Rivers, Holland Brook, Pleasant Run, and other smaller streams In a few places it occupies the flat tops of hills. The drainage is usually excessive, especially on the slopes, and here, too, the soil is subject to much damage from erosion. Crops often suffer from lack of moisture in dry seasons.

The Penn shale loam is nearly all cleared, except in a few places where the slope is steeper than common and the parent rock is very close to the surface. White oak and hickory predominate in most of the forested parts; in a few places beech is abundant. The type is used mainly for growing the general farm crops, in conjunction with dairying. The cows as a rule are pastured on adjacent bottom soils.

flatter, more nearly level country in the unglaciated part of the Triassic region. In a few places the surface is gently sloping. The type is well drained. In areas in which the depth to bedrock is shallower than ordinary, crops are likely to suffer from drought.

The Penn silt loam is nearly all cleared, the existing forested areas for the most part consisting of 5 to 10 acre tracts used for farm woodlots. The forest growth consists of red oak, white oak, chestnut oak, and other varieties of oak, hickory, maple, ash, some walnut, and sassafras. The most important crops are corn, oats, wheat, timothy and clover hay, rye, and buckwheat. (See Pl. XVI, fig. 1.) Large quantities of peaches are grown, though the industry is less important than formerly, the Penn soils not being considered as good for fruit production as the Montalto and Chester soils. Alfalfa, steadily becoming a more popular crop, seems to do well. Vegetables, small fruits, apples, pears, plums, and quinces are grown by most of the farmers to supply the home, and there is usually a surplus for sale. Some commercial orchards are located on the type (Pl. XVI, fig. 2). Dairying is the most important industry. Nearly every farmer has from 6 to 20 cows or more, usually grade Holsteins, and there are a few purebred herds. The milk is hauled to the nearest milk station, where it is iced and shipped to near-by cities. At Readington there is a factory where the whole milk is first put through a separator; the cream is sold to the city markets and the skim milk is made into a dry curd and shipped to factories for the manufacture of such articles as buttons. A few farmers make butter for town customers, but this is not a common practice. Poultry raising is an important business. It is usually carried on more as a side line, but a few farmers make this their main business. Hogs are raised on nearly every farm, but not many produce more pork than is sufficient to supply home needs.

A considerable part of this type has been under cultivation for 100 to 150 years, and as far as ascertained the yields are as large as they ever were. The yield of wheat ranges from 15 to 25 bushels per acre, with an average of about 18 bushels. Oats average between 30 and 35 bushels, and hay 1 to 1½ tons per acre.

The crops are grown by nearly all farmers in rotations. Corn is followed by oats and oats by wheat or rye. Timothy is seeded with the wheat or rye and clover is seeded in the spring upon the young timothy, with a wheelbarrow seeder. The common practice has been to allow the grass to stand for at least two years, but many of the farmers now cut hay only one year, making a four-year rotation. This change is due to the decreased demand for hay in the cities. The soil is well tilled, with heavy teams and improved machinery. Many are using small tractors for plowing. Silos are becoming more

The value ranges from about $25 to $70, depending mainly upon improvements.

LANSDALE SHALE LOAM.

The Lansdale shale loam consists of a light-brown to chocolate-brown silt loam, overlying yellowish-brown to yellow moderately friable clay or silty clay loam. Fragments of chocolate-brown, gray, and brown shale are abundant, the quantity increasing with depth in places. The parent bedded shale is usually encountered at depths ranging from about 20 to 36 inches.

Northwest of Gladstone is a ridge occupied by Berks shale loam, which, because of its small extent, has been included with this soil. The Berks shale loam is a light-brown silt loam, about 8 inches deep, overlying brownish-yellow silty clay. The bedrock in most places lies within 20 inches of the surface. The soil is filled with thin platy fragments of brown and dark slate-colored shale. It is much like the Lansdale shale loam.

The most important bodies of the Lansdale shale loam occur in the vicinity of Neshanic, Centreville, Basking Ridge, Liberty Corner, and Gladstone. The total area is small. Drainage is excessive in most places, and crops planted on it often suffer from drought.

The type is nearly all cleared and is used for the general farm crops common to the section. Apples and peaches do well with proper cultural methods. Potatoes and alfalfa are grown by a few farmers. Dairying is important. The yields, except in very wet seasons, are somewhat lower than on the silt loam and loam soils of the area. It has a wide range in value, owing to the fact that some of it is situated in the parts of the area desirable for suburban residence. For strictly farming purposes its value is not as high as that of many of the other soils.

In other localities this soil, the included Berks shale loam particularly, is used with marked success for the growing of Irish potatoes. The steeper slopes should be kept in grass or allowed to revert to forest, as they are subject to erosion. Cover crops should be used more extensively on nearly all of the farms, and the legumes, such as soy beans, sweet clover, and clover, should be grown more generally as soil improvers.

LANSDALE SILT LOAM.

The surface soil of the Lansdale silt loam consists of a light-brown, brown, or chocolate-brown mellow silt loam 8 to 10 inches deep. The subsoil begins as a yellowish-brown friable silty clay loam, but passes downward into a yellow or yellowish-brown friable silty clay. In a few areas the lower subsoil has a reddish cast, but this is not typical. Some brown or gray shale fragments are found here and there. In the area mapped on Sourland Mountain the soil is derived from dark-bluish argillite, and bedrock is reached, in places at least, within the 3-foot section. The subsoil has essentially the same color as the parent rock.

Many patches of this soil were mapped near Centreville, Readington, Neshanic, Neshanic Station, and Basking Ridge. The topography ranges from nearly flat to gently sloping or rolling. The drainage is well established.

This is not an extensive soil type. Almost all of it has been cleared and is devoted to the same crops as the Penn silt loam, with which it is closely associated. It is handled in the same manner and gives about the same returns as the latter type. The value of the two soils is the same where they are similarly situated.

CROTON SILT LOAM.

The surface soil of the Croton silt loam is a gray silt loam with an average depth of 8 to 10 inches. The subsoil is a yellow or pale-yellow plastic clay mottled with gray, passing into a stiffer clay, which below about 24 inches consists of a tough, compact clay or clay pan mottled yellowish brown and bluish gray. In some places the clay-pan layer is not reached above 30 inches, and varies from dull brown to mottled yellow and gray in color. Some of the smaller areas included with this type are brown or red in the surface soil, with mottled material below. The type as mapped also includes some silty clay loam. On Sourland Mountain some large argillite fragments are present. These are indicated on the map by stone symbols.

The Croton silt loam occurs in a great many rather small patches scattered over the southwestern quarter of the area. It is found in small depressions or flats, often at the heads of small drainage ways.

torily. It affords good pasturage during most of the season, and should, where possible, be used for this purpose.

SASSAFRAS SAND.

The Sassafras sand, as mapped in this area, consists of a brown sand, with a thin layer of light-gray sand at the immediate surface in the wooded sections, underlain at depths of about 5 to 7 inches by an orange-colored to reddish-yellow sand of a somewhat loamy structure. There are some included unimportant patches of Sassafras sandy loam, Lakewood sand, and Norfolk sandy loam, deep phase. Fragments of a red ironstone and gravel are present in places.

The Sassafras sand occurs in the southeastern corner of the area, east of New Brunswick and near Sayreville. It is a well-drained soil.

The type is of very little importance in the agriculture of the area. It is nearly all undeveloped. Near the industrial town of Sayreville most of the cleared land has been dug over for the underlying clay. The native growth consists of several kinds of oak, sassafras, and other trees. The land is used to a small extent for garden vegetables and general farm crops. It is handled in about the same way as the Sassafras sandy loam.

SASSAFRAS SANDY LOAM.

The Sassafras sandy loam consists of a brown sandy loam, 8 to 10 inches deep, overlying yellowish-red sandy loam, which grades into sandy clay or coarse sandy clay of reddish-yellow color. Some small quartz gravel is scattered over the surface in most places, and reddish Triassic gravel appears in many of the areas on the north side of the Raritan River. The area near Bonhamtown contains enough coarse sand to give a texture approximating coarse sandy loam. The areas east of Bonhamtown and those southwest of that place on the north side of the river are situated in the vicinity of large clay pits, which are indicated on the map by the mine symbol. The area mapped east of Sayreville is considerably mixed with other soils, which could not be satisfactorily separated, owing to the small size of the areas. In places in this section the surface soil is a brown loamy sand, which grades into reddish-yellow sandy loam with mottled gray and yellow clay coming in below. On the shoulders of some of the small hills this clay is at or near the surface.

The type is associated with the other members of the Sassafras series on both sides of the Raritan River. It occurs in gently rolling to gently sloping areas and has good drainage.

It is nearly all cleared, and is used for growing corn, wheat, hay, and oats. There are many large gardens on it, where truck crops are grown for sale. Most of this land is owned or used by men who labor in the clay pits or in the small near-by towns and farm only in

reddish-yellow friable sandy clay. Usually the lowe sandy than the upper subsoil. In many places the a reddish-yellow friable sandy clay. In places th rather gritty. Included with the type, as mapped town, are some small areas of sandy loam, sand, and Portsmouth loam and Muck. In the wooded areas t layer is not nearly as deep as in cultivated fields.

The largest and most important areas of this soil o town, Piscataway, south of Metuchen, and near N Its surface is nearly flat to gently rolling. The land except in the included depressions, commonly contai which were mapped with this type because of their s

The Sassafras loam is not of great importance in t the area, though it is the most extensive of the Sassaf of it is located in and near the city of New Bruns veloped section near Piscataway, and around Bonh of it is still covered with oak forest. In some sectio farming, corn, oats, wheat, rye, and hay being th Some alfalfa is grown and does well. A number of fa to growing truck crops for near-by city markets. ' Experiment Station is located in part on this soil. managed give very good returns, for it is a soil readily to good cultural methods including crop r use of manure and commercial fertilizer. Its value favorable situation for residence sites.

the soil is a light-gray or bluish-gray silty clay loam, grading into light bluish gray silty clay loam or silty clay, compact in places, and dry in the lower subsoil, owing to the impervious character of the overlying material. Gravel and sand are found at depths of about 3 feet in these hummocks. In places the surface soil is a light-gray sandy loam, and again some areas have a dark-gray or brown layer at the surface. Included with the type are some small areas of poorly drained alluvial soil occurring along the borders of very small streams.

The Elkton clay loam occurs mainly between Piscataway and Metuchen. One area lies near the New Jersey Experiment Station in New Brunswick.

This is a low, imperfectly drained soil occurring in depressions and flats. The greater part of it is covered with a growth of pin oak, sweet gum, swamp maple, hickory, elm, sycamore, birch, and ferns.

BIRDSBORO SILT LOAM.

The Birdsboro silt loam is a chocolate-brown or reddish-brown silt loam, 8 to 12 inches deep, overlying lighter Indian-red silty clay loam containing more or less grit. The extreme lower subsoil in places has a deeper Indian-red color, and varies from a friable gritty clay to a sandy loam. Gravel of quartz, red sandstone, trap rock, and quartzite is abundant locally in the lower part. In places quantities of gravel are present on the surface and scattered through the 3-foot section. These gravelly areas are shown on the soil map by gravel symbol. Included with the type, as mapped near Woodfern, is an area in which both surface and subsoil consist of chocolate-brown sandy loam.

The Birdsboro silt loam is developed on flat to slightly undulating terraces in Somerset and Middlesex Counties. The largest and most important bodies occur along the branches of the Raritan River. It is a well-drained soil.

The type is not extensive, but nearly all of it is cleared and in cultivation. The general farm crops of the region, corn, oats, wheat, and timothy and clover hay are grown, together with some rye and buckwheat. Alfalfa does well and is important in many places. Dairying is practiced on nearly every farm, the cows being pastured on the rather wide first-bottom soils that lie adjacent to this type. The milk is usually sold to a local receiving station, where it is shipped whole to the large city markets. The farmers nearly all raise enough pork, vegetables, fruit, and poultry to supply their own wants, and many have a surplus of these products to sell. Crop yields are equal to if not a little better than those obtained on the near-by Penn silt loam.

The crops are grown in rotations, and good tillage methods are used. Improved farm machinery is common, and in recent years many owners of this soil have purchased small farm tractors. T type is considered a good, strong soil, even better than the Penn loam, and often brings from $10 to $20 more an acre.

Below are given the results of mechanical analyses of samples the soil and subsoil of the type:

Mechanical analyses of Birdsboro silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Cl
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per*
170960	Soil	1.9	7.2	3.4	8.9	12.4	50.2	
170961	Subsoil	.7	6.0	3.4	8.9	12.0	47.4	

ROANOKE SILTY CLAY LOAM.

The Roanoke silty clay loam, to a depth of about 4 to 6 inches a gray to whitish silty clay loam to heavy silt loam, underlain mottled gray and yellow or bluish-gray and yellow silty clay lo which passes into bluish-gray or a mottled gray and yellow silty cl with a tough clay layer at depths ranging from 15 to 24 inches. T material in this layer has a mottled bluish, red, yellow, and gray co and the structure of a clay pan. In forested areas the gray surf layer is only 1 or 2 inches thick.

This type is associated with the Birdsboro silt loam, occurring the second bottoms of the North Branch of the Raritan River and tributaries. The largest and most important areas are east of Bu Mill, near Lamington, southwest of Bedminster, and in other pla in this same general region. It occurs on flat or depressed areas a black, or bluish silty clay loam to silty clay extending to 3 feet or more. In places the lower part of the subsoil consists of bluish-gray loamy sand or sandy loam. Included with the type as mapped near Green Village and northwest of Hanover Neck there are small areas having a surface soil of brown silt loam, 6 to 8 inches deep, and black muck or black silty clay in the lower part of the 3-foot section.

The type occurs in the swampy, poorly drained first bottoms of many of the streams in the glaciated sections of the area or along the streams which flow from these sections. The largest and most important developments are on the upper part of Black River, here and there along the Passaic River, along Great Brook, and in a number of other places in the western and northern parts of the area. In its native state it supports two types of vegetation: (1) Rushes and other water-loving grasses and sedges, in the wetter areas, and (2) a growth of swamp maple, sweet gum, pin oak, elm, hickory, and bushes in areas less wet. Some large tracts have been cleared and at least partly drained. These are used with other bottom soils for pasture.

PAPAKATING SILTY CLAY LOAM.

The Papakating silty clay loam consists of a dark-gray, brown, or brownish-black silty clay loam, passing into a mottled gray and yellow, blue, or black, plastic, heavy clay. In places the lower subsoil is a very tough dark-brown clay, mottled with gray.

This type is of the same origin and is found in the same relative positions as the Papakating silt loam. The two soils are alike in being very poorly drained, and the tree growth is the same on both. Where used at all the type is used for pasture.

PODUNK LOAM.

The Podunk loam consists of a brown, dark-brown, or grayish-brown loam, ranging in places to silt loam, underlain at 8 to 12 inches by a yellow or brown sandy or gritty clay, which becomes more sandy below and has here and there a slight reddish cast. In places the subsoil is mottled with gray and yellow, but this mottling is not typical and rarely occurs in the upper subsoil. Gravel, cobblestones, and bowlders of gneiss are abundant in many places.

This type is developed along the streams of the northern and eastern parts of the area. It is a first-bottom soil, composed of materials which have been washed from the Gloucester soils. The largest areas lie along the Passaic and Rockaway Rivers, where they are associated with the Papakating soils. The Podunk loam is much better drained than the Papakating soils. It is used for the most part as pasture and makes excellent grazing land during even the hottest summer months. A little of it is used for the production of corn, hay, and truck crops, but as the land is overflowed these crops are subject to more or less damage.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the type:

Mechanical analyses of Podunk loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
170919............	Soil.........	2.9	9.8	4.3	12.5	13.4	37.9	19.2
170920............	Subsoil......	6.0	12.1	4.6	11.1	11.7	36.9	17.5

CODORUS LOAM.

The typical Codorus loam consists of a brown to light-brown, mellow, gritty loam, overlying a light-brown to yellowish-brown loam, which becomes more sandy in the lower part of the 3-foot section. As mapped in this area the type lacks uniformity. In many places the subsoil varies from clay to sand. Included with the type are some patches of Codorus sand and Codorus sandy loam. Mica flakes are usually present in the soil and subsoil, but they are not so abundant as in some areas of Codorus soils mapped in parts of Pennsylvania. Gneiss gravel, cobblestones, and bowlders are present in some places. In sections where this soil is composed of wash derived from the Montalto soils the surface soil in places is a reddish-brown loam to silt loam and the subsoil is a brown sandy loam to silty clay.

The Codorus loam occurs along the streams flowing through or from the Chester and Montalto soils and represents material washed o soils. In extent and use it is of minor importance in the area. ıch of it is still covered with pin oak, maple, birch, hickory, elm, eds, and grasses. Where cleared it is used as pasture land.

BERMUDIAN SILT LOAM.

The Bermudian silt loam is a dark reddish-brown or chocolate-own silt loam, grading into dark Indian-red, friable, heavy silt ım to silty clay loam at depths of about 10 to 12 inches. This ually extends to 3 feet or more without much change. In many aces a lighter more friable layer is found in the lower part of the foot section. There are a few wet, mucky, or swampy places in any of the larger areas, and here the subsoil is usually heavier and mottled with gray and yellow. These wet spots occur on patches o small to map. Small rounded gravel, mostly of red sandstone, found here and there. As mapped along the small streams flowing rough and out of the Wethersfield and Dunellen soils in the south-astern part of the area, as near Metuchen and Westfield, the type variable, though for the most part it has a reddish surface soil and ubsoil. There are, however, included areas in this region where he surface soil is brown and the subsoil a brown or yellowish-brown ilt loam. The typical material is derived almost entirely from ash from the upland soils of the Penn series.

The Bermudian silt loam occurs in the southern part of the area long streams flowing through areas of red Triassic shale and sand-tone. It is a fairly well-drained soil, except during periods of verflow.

The type has been cleared of most of its native timber. Along the anks of the larger streams, willow, elm, and walnut are found. This oil is used mainly as pasture land, for which purpose it is highly prized. It supports an excellent stand of pasture grasses which re-main green even during long droughts. On nearly all farms the number of cows kept is in direct proportion to the acreage of bottom-land pastures. In places horses, sheep, and hogs are grazed in these pastures along with the dairy cows. In a few places in the wider bottoms along the Raritan River the land is cultivated, the general farm crops being grown. There is some risk of losing the crops, though the wide bottoms are not often overflowed during the grow-ing season. In the summer of 1919 large acreages of wheat, corn, oats, rye, and other crops were ruined by floods, and in places grain that had been cut and was standing in the fields in shocks was washed downstream.

MUCK.

Muck consists of black, well-decomposed vegetable matter, with some intermingled inorganic or mineral soil material, such as sand, fine sand, and silt. The organic deposit is 24 inches or more deep (an 8-foot auger was used in one place in the Black Meadows, but the bottom of the deposit was not reached). This is underlain by a pale yellowish gray loam or gray silty clay, sandy clay, or clay. In places there is no clay layer, and the lower subsoil is a gray or greenish-gray sand. A mass of brown peaty material is encountered in places at a depth of about 15 inches and continues downward to the sand or clay stratum. In the uncleared areas the surface inch or two of the material contains the undecayed roots of grasses and shrubs.

Three classes of Muck have been shown on the map: (1) Typical Muck, (2) an intermediate phase, and (3) a shallow phase. It was not possible everywhere to separate the small areas of these, and therefore in places small patches of the phases are included with the typical Muck. In the large swamps also there are a few small ridges of Whippany and Merrimac soils, which, owing to their small extent, could not be separated on the map.

Important areas of typical Muck occur in the Black Meadows, Great Swamp, Troy Meadows, and in the smaller swamps near Ledgewood Station, near Budd Lake, and in a great many other places scattered here and there throughout the glacial section of the area. It is a poorly drained soil, and unless drained nothing can be done with it. Most of it is covered with a tree growth including pin oak, swamp maple, birch, willow, and sycamore. Mosses and grasses growing in tussocks are common, and there are many places covered with marsh grasses and other plants where there are no trees.

These areas of Muck, situated, as most of the large ones are, within 30 miles of New York City, could be developed and converted into very valuable land. A considerable acreage of Muck has been at least partly drained, but there are really no very large areas that

To reclaim completely the large areas, known as the Great Swamp, Black Meadows, and the Troy Meadows, would involve the expenditure of large sums and require the services of an expert drainage engineer. It is believed these areas could be drained economically with a view of using them in production of onions, celery, and similar crops.

Muck, intermediate phase.—The intermediate phase of Muck consists of black organic soil exactly like the typical Muck, except that it occurs in shallower deposits, the layer of decomposing vegetable matter ranging in depth from 10 to 24 inches. It is associated in most places with the typical Muck, but here and there in the northern and western parts of the area small patches of this phase occur alone. Like the typical Muck, this phase has not been reclaimed to any great extent.

Where drained it is used for the same purposes as the areas of deeper deposits. In other places outside of this area, where it has been reclaimed on an extensive scale, the yields are stated to be about the same as the typical Muck. The latter, however, is held at somewhat higher prices.

Muck, shallow phase.—The shallow phase of Muck differs from the typical and the intermediate phase in that the organic deposit is not more than 10 inches deep, most of it ranging from 7 to 10 inches. The underlying material in most cases is a gray or greenish-gray sand or a brown to gray silty clay, sandy clay, or clay. In some places where clay is found in the upper part of the subsoil, the lower part of the subsoil is a gray or greenish-gray sand or loamy sand. There are included with this phase small patches of typical Muck, and of the intermediate phase, some Clyde loam, and, in a few places, some Merrimac and Whippany soils; but these occur only in patches too small for satisfactory mapping. Only a small total area of the shallow phase is mapped in the Bernardsville area. When reclaimed, the shallow soil yields about as well as the deeper Muck.

TIDAL MARSH.

Tidal Marsh is the term applied to low tidal flats covered with grass. The soil material usually consists of brown silty clay loam or silty clay grading into black or dark bluish silty clay. In places the material is black from the surface down, and is often very mucky; that is, high in content of decaying vegetable matter. Considerable quantities of organic matter consisting of the roots and leaves of grasses in all stages of decay are found near the surface in nearly all places.

The Tidal Marsh mapped in this area occurs about the mouth of the Raritan River. "Salt hay" is cut from this marsh, and is used by factories for packing breakable goods, and to some extent as coarse feed and bedding for horses and cattle. Similar marshland in southern New Jersey near Millville and elsewhere has been diked, draine and used very successfully for the growing of strawberries, tomato and other truck crops, as well as for hay and corn.

ROUGH STONY LAND.

Rough stony land includes rough areas, mostly steeply sloping, covered with fragmental rock and so cut by rock outcrops that th have little or no agricultural value. Gneiss, sandstone, and sh occur through the soil. The greater part of this classification rep sents rough stony areas of Chester and Gloucester soil, but sm areas of Montalto and Penn types occur. The soil material betwe the stones does not differ in character from typical soils of these seri

Rough stony land occurs most extensively in the mountain sectio of the area, where it is confined largely to very steep topograph It is forested land, supporting the same types of forest as the s types associated with it in the different localities where it occu It is valued almost wholly for its timber, and its best use is for forestr

CLAY PITS.

Certain areas have been rather thoroughly worked over in the pro ess of getting out the underlying deposits of clay for industrial use These areas comprise pits and soil-refuse dumps, and have no val for agriculture. They occur within or adjacent to areas of the Sass fras soils and are shown on the map by the word "clay" and t mine symbol.

SUMMARY.

The Bernardsville area is situated in the central part of norther New Jersey. In outline it is rectangular. It contains parts of

The climate is marked by a rather wide range in temperature, hough extreme temperatures are of short duration. The rainfall is ufficient and well distributed throughout the growing season. The ength of the growing season varies from 157 days in the northern ections to 181 days in the southern end of the area.

The agriculture consists of the growing of general farm crops, such as wheat, corn, rye, timothy, clover, and buckwheat, in conjunction with dairying. Poultry, fruit, and truck are important in many places.

The soils of the area lie in seven soil provinces, viz, Piedmont, Appalachian Mountain, Coastal Plain, Glacial, Glacial Lake and River Terrace, Limestone Valleys, and River Flood Plains. Forty-eight eparations were mapped.

The Washington soils are perhaps the most popular of the glacial soils for general farm crops. The Gloucester soils are well suited to the production of fruit, especially apples. The Wethersfield soils are good strong soils, but owing to their situation near the suburban districts of New York City they are not used extensively for farming. The loams and gravelly and stony loams are the most important types.

The Merrimac and Dunellen soils are good strong soils. The loam types are used for the production of general farm crops; the sandier types are excellent for truck crops, for which in some places they are extensively used. Many of the areas occupied by these soils are near the large centers of population and are used largely for building sites.

Muck is extensive, but as a whole has not been developed as it has been in other parts of the State. Its chief use at present is as pasture for dairy cattle during dry seasons.

The Whippany and Clyde soils need drainage and liming. The Clyde soils could be made to grow celery and lettuce if treated properly. At present these soils are used to some extent for general farm crops, though corn and clover do not do as well as many other crops. Large tracts of these soils are used for pasture.

The Chester soils are strong, productive, well-drained soils and very similar to the Gloucester soils. They are well suited to fruit production, especially peaches and apples.

The Hagerstown silt loam is the only type mapped in the Limestone Valley soil province, and is small in extent. It is an excellent soil for general farm crops, and seems well suited to the production of alfalfa.

The Piedmont Plateau soils are classed into two main divisions: (1) Those derived from sedimentary rocks, the Penn, Lansdale, Croton; (2) those derived from crystalline rocks, the Montalto and Watchung. Of the first group the Penn and Lansdale soils form good farm lands of about equal agricultural value. Some areas are of relatively low value because the parent rock is too close to the surface and crops suffer from drought. The main types are the silt loams and shale loams, though the gravelly loams are important in places. The Croton silt loam is poorly drained and is not a popular farm soil. The shallow-rooted crops, such as rye, oats, and timothy, are the most successful. Corn, wheat, and clover do not do well.

The Montalto soils are well suited to fruit production and the growing of general farm crops. Many areas of these types are rather stony or occur on rough, broken topography. However, there are large tracts which are stone free, have a favorable topography, and are highly prized. The Watchung soils are the poorly drained equivalent of the Montalto, and in agricultural use are similar to the Croton soils.

The Sassafras and Elkton soils are mapped in the Coastal Plain province. The Elkton clay loam is poorly drained and low in agricultural value. The Sassafras soils are well drained and productive. The sandier types are highly prized in other sections of the State for truck crops. They occur in this area near the suburban sections and are not used to any great extent for farming. Large tracts have been dug over in mining the underlying clay deposits.

The soils of the River Flood Plain province are of many different kinds. Two second-bottom or terrace types are mapped—the Roanoke silty clay loam and the Birdsboro silt loam. The former is very poorly drained and is used mainly as pasture. The Birdsboro is developed on alluvial material derived from the Piedmont region. It is an excellent soil for wheat, clover, timothy, alfalfa, rye, and oats.

The first-bottom soils are used chiefly for pasturing dairy cattle. They are very well suited for pasture, as the grass remains green and

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS.

IN COOPERATION WITH THE DEPARTMENT OF CONSERVATION AND
DEVELOPMENT OF NEW JERSEY.

OIL SURVEY OF THE CHATSWORTH AREA, NEW JERSEY.

BY

L. LEE, In Charge, C. C. ENGLE, and WILLIAM SELTZER,
of the Department of Conservation and Development
of New Jersey, and AUSTIN L. PATRICK and
E. B. DEETER, of the U. S. Department
of Agriculture.

[Advance Sheets—Field Operations of the Bureau of Soils, 1919.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1923.

[PUBLIC RESOLUTION—No. 9.]

**JOINT RESOLUTION Amending public resolution numbered eight,
second session, approved February twenty-third, nineteen hundred
for the printing annually of the report cn field operations of t
Department of Agriculture."**

Resolved by the Senate and House of Representatives of th
America in Congress assembled, That public resolution numl
sixth Congress, second session, approved February twenty-th
dred and one, be amended by striking out all after the resol
serting in lieu thereof the following:

That there shall be printed ten thousand five hundred cop
field operations of the Division of Soils, Department of Ag
one thousand five hundred copies shall be for the use of the
sand copies for the use of the House of Representatives, and
for the use of the Department of Agriculture: *Provided*, That
number of copies above provided for there shall be print
manuscript can be prepared, with the necessary maps and ill
pany it, a report on each area surveyed, in the form of adv
in paper covers, of which five hundred copies shall be for th
tor from the State, two thousand copies for the use of each
the congressional district or districts in which the survey
thousand copies for the use of the Department of Agricultur

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as t

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ILLUSTRATIONS.

PLATE.

PLATE XVII. Geographic provinces of New Jersey..............

FIGURE.

FIG. 10. Sketch map showing location of the Chatsworth area, Ne

MAP.

Soil map, Chatsworth area, New Jersey, eastern sh
Soil map, Chatsworth area, New Jersey, western s

SOIL SURVEY OF THE CHATSWORTH AREA, NEW JERSEY.

L. L. LEE, In Charge, **C. C. ENGLE,** and **WILLIAM SELTZER,** of the 'epartment of Conservation and Development of New Jersey, and **AUSTIN . PATRICK** and **E. B. DEETER,** of the U. S. Department of Agriculture.

DESCRIPTION OF THE AREA.

The Chatsworth area is situated in the southeastern part of New sey, and is bounded on the east by the Atlantic Ocean. It includes of Ocean County, about half of Burlington County, one-third of antic County, and small parts of Monmouth and Camden Counties. s bordered by the Camden area on the west, the Millville area on south, and in part by the Freehold area on the north. The area a maximum length of 45 miles and its greatest width is 37 miles. ncludes all of atlas sheets No. 32 and . 33 and approximately half of sheet . 29 of the New Jersey Geological Sur- ˜, and contains 1,195 square miles, or :,800 acres.

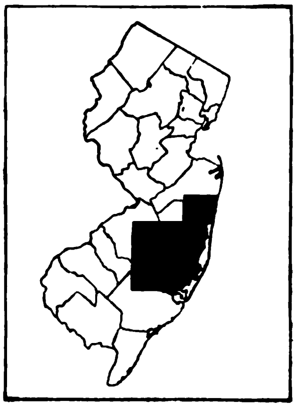

FIG. 10.—Sketch map showing location of the Chatsworth area, New Jersey.

:he Chatsworth area is one of very ht surface relief over wide areas. (See I.) Isolated hills, rising abruptly from to 80 feet or more above the surround- country, are in such striking contrast the prevailing surface that they are ılly called "mountains." There are ny low and swampy areas, especially ;he vicinity of Browns Mills, Chats- :th, Batsto, Harrisia, and Double ›uble. The northeastern part of the a shows the greatest relief, the undu- ing to gently rolling topography standing out in bold contrast to › flat almost level plain to the south and west.

The range in elevation is from sea level to about 200 feet, the ele- tion of Apple Pie Hill, 3 miles southwest of Chatsworth, in the st-central part of the area.

The general drainage slope is to the east and southeast to the lantic Ocean, and to the southwest to the Delaware River. The st of the drainage divide, which is relatively flat, passes approxi- tely through Tabernacle, Woodmansie, and Whitings in an irregu- northeast-southwest direction.

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ing parts of their courses, the area is well draine
swampy areas lie near the heads of streams tributary
and Wading Rivers, and the two branches of Rancoc

In places, as at Pleasant Mills and Wells Mills, som
has been developed by damming the local stream
Atsion, Tuckerton, Harrisia, Cedar Crest, Manahawken
and Double Trouble ponds or artificial lakes have b
the construction of dams and flood gates. Most of
voirs for the storage of water used in flooding cranb
Lakehurst, Lakewood, and Browns Mills small lake
boating and fishing by guests of these resorts.

Several bays indent the coast line. Barnegat Bay
about 20 miles long and from 2 to 5 miles wide. Ma
and Little Egg Harbor are farther south. All these
with the open sea through Barnegat Inlet.

The native forest consists mainly of pine and oaks.
the growth is scrubby or stunted, as the result of fire
tions or both. The oaks include blackjack oak, scrub
chestnut oak, and white oak. Pitch pine predomina
evergreens, with some shortleaf pine. There are abun
able stands of white cedar in most of the swamps. In
country the forest is predominantly pitch pine with a
oak; on the heavier, well-drained soils the ratio is rever
growth is abundant, except on the plains and in some e
areas. It consists mainly of scrub oak, huckleberry, cr

ch and Swedes made the first settlements, later followed by the lish. Part of Burlington County was annexed to Ocean County veen 1890 and 1900.

he present population consists chiefly of descendants of the early ers, together with a considerable number of foreign birth. Ocean ty is comparatively thinly settled, the population in 1920 being 55, or 34.8 persons per square mile. There being no town with than 2,500 inhabitants, all the population is classed as rural. 920 Burlington County had a population of 81,770, of which per cent are classed as urban and 80.5 per cent as rural. The population has a density of 80.7 persons per square mile, but more densely populated part of this county is not included in hatsworth area. Atlantic County in 1920 had a population of 4. Of this only 21.8 per cent were classed as rural. The ty of the rural population is 32.1 persons per square mile. of those listed as urban are in Atlantic City, which is outside mits of the Chatsworth area. The figures for Burlington County airly representative for that part of Monmouth County included e surveyed area.

ne population centers of the Chatsworth area are along the sea- t, railroads, and larger river valleys. Settlement is especially se in the central part, there being many square miles in this part out a single inhabitant.

akewood, in the northeastern part of the area, with a population ,110 in 1920, is the largest town.[1] Toms River, the county seat cean County, has a population of about 2,000[2] and is important n agricultural center as well as a summer resort. Manasquan, a population of 1,705, is an important agricultural center. berton has 800 inhabitants and is the most important town in northwestern part of the area.

he northeast coast resorts, of which Spring Lake, Sea Girt, Bel- , and Point Pleasant are the most important, have permanent ulations ranging from a few hundred to 2,000, which is approxi- ely the population of Belmar. During the summer months y city families make their homes at these resorts. Farther th Bay Head, Mantoloking, Lavalette, Seaside Park, Barnegat r, and Beach Haven are resorts of less importance. Toms River, nd Heights, and Beachwood also have many summer visitors, the two latter have only a small permanent population.

uckerton, with a population of 1,106, and Egg Harbor, with 22, are the only towns of importance in the southern part of the a. Only a part of Egg Harbor City is included within the bound- s of the Chatsworth area.

Not incorporated. Population given is that of township.

Estimated.

outlet to New York City, and another line of this Barnegat and other towns to the north along B transportation direct to New York. A line of the road system connects the northern part of the delphia and the coast resorts, and a branch of this Dix and Trenton via Pemberton. The Tuckerto the bay shore towns farther south, and at Whitin nections to Philadelphia and New York.

The county roads of the area as a whole are loose sandy surface, together with the numerous swampy sections, make travel difficult over many better developed sections, however, there are man roads. The three main trunk-line roads carry a between the larger cities to the north and west Lakewood, and other coast resorts.

The metropolitan districts tributary to New York together with the coast resorts, are the chief mark ucts, but cranberries are shipped to all parts of t

CLIMATE.

The climate of the Chatsworth area is some might be expected for the latitude, the ocean h influence on both summer and winter temperatu are not as severe or as long as in northern New Je mers are relatively cool. The snowfall is usual melts, especially along the seacoast.

The rainfall is everywhere sufficient for successf

The tables below, compiled from the records of the Weather ureau stations located at Lakewood in the north and at Tuckerton the south, give the normal monthly, seasonal, and annual temrature and precipitation applicable to the area surveyed.

Normal monthly, seasonal, and annual temperature and precipitation at Lakewood.

[Elevation, 54 feet.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1904).	Total amount for the wettest year (1903).
	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
cember	33.8	68	−11	3.72	3.77	3.74
nuary	32.1	71	−7	3.78	2.25	4.44
bruary	29.8	66	−4	3.85	2.47	4.46
Winter	31.9	71	−11	11.35	8.49	12.64
rch	40.0	78	6	4.43	3.83	4.69
ril	49.7	93	18	3.73	3.70	3.46
y	60.5	97	29	3.86	5.11	1.02
Spring	50.1	97	6	12.02	12.64	9.17
ne	67.6	95	40	3.67	2.70	6.62
ly	72.9	98	45	5.03	5.55	7.36
gust	70.7	97	43	5.07	6.01	8.77
Summer	70.4	97	40	13.77	14.26	22.75
ptember	65.4	91	34	3.88	2.48	3.35
tober	55.3	88	22	3.70	2.48	8.17
ovember	43.2	76	14	3.65	1.91	1.02
Fall	54.6	91	14	11.23	6.87	12.54
Year	51.7	97	−11	48.37	42.26	57.10

Normal monthly, seasonal, and annual temperature and precipitation at Tucke

[Elevation, 23 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1896).	Total amount for the wettest year (1903).	Sr av de
	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*	*In*
December	37.5	70	−8	4.28	0.94	4.52	
January	31.7	73	−13	3.66	1.50	4.55	
February	32.1	68	−6	3.79	6.82	6.28	
Winter	33.8	73	−13	11.73	9.26	15.35	
March	39.0	84	−1	4.39	3.63	8.07	
April	47.9	92	19	3.79	1.17	4.19	
May	59.7	98	28	3.43	2.71	.76	
Spring	48.9	98	−1	11.61	7.51	13.02	
June	69.0	102	38	3.57	4.47	8.02	
July	74.1	103	42	.88	2.81	7.17	
August	72.2	102	44	5.78	1.27	6.55	
Summer	71.8	103	38	10.23	8.55	21.74	
September	66.0	96	32	3.36	1.37	2.87	
October	54.8	92	21	3.67	3.16	9.41	
November	44.0	76	10	3.46	1.93	1.44	
Fall	54.9	96	10	10.49	6.46	13.72	
Year	52.2	103	−13	44.06	31.78	63.83	

AGRICULTURE.

parently is of a character better suited to forestry than to agri- ture.

Considerable areas heretofore occupied by remnants of forest have recent years been cleared for fruit, berry, and truck farms. Such ilization of the land is justified when the agricultural possibilities the soil are known. Those areas off the improved highways how- er, and far from markets, unless of the better grades of soil, should brought into cultivation, if at all, only after very careful consid- tion of all the factors involved in successful agriculture.

The census figures for Ocean County, which lies wholly within area, are representative of a large part of the included sections Burlington and Atlantic Counties. Corn was planted in Ocean nty on 5,042 acres in 1899, and on 4,336 acres in 1919. In 1899 e were 1,898 acres of rye, 54 acres of oats, and 167 acres of at, and in 1919 there were 1,770, 99, and 61 acres, respectively, hese crops.

n 1899 there were 7,486 acres devoted to hay and 608 acres in ge crops. In 1919 the hay and forage crops occupied 7,146 acres, which 4,709 acres were in wild hay, 1,984 acres in tame hay, mainly othy and clover, and smaller acreages in silage and coarse forage ps.

The production of special crops, such as Irish potatoes, sweet tatoes, and other vegetables, is a well-established industry that s varied very little during the last 30 years. In this county cran- rry production has suffered a marked decline. In 1899 there were '84 acres of cranberry bog; in 1919 only 736 acres were under tivation. Between 1899 and 1919 the number of apple, pear, and ach trees decreased from 76,415 to 18,369. Grapevines decreased number from 9,364 vines to 2,377 vines during the same period. In the production of poultry products, however, a marked con- st is apparent. From 1900 to 1920 the number of chickens in ean County increased from 34,134 to 64,882. The value of poultry d eggs produced in 1919 was reported as $475,080. There were 68 dairy cows reported in 1900 and 1,901 cows in 1920. The lue of dairy products, excluding milk and cream used on the farm, reased in 20 years from $37,269 to $149,763. It can readily be n that other types of farming are rapidly giving way to poultry sing and dairying, especially the former.

Except for the poultry and dairy industries, farming appears not be making any noticeably forward strides at the present time in ean County, or in similar parts of Burlington and Atlantic Counties cluded in the Chatsworth area. In these parts of Burlington and lantic Counties, however, neither poultry nor cattle are raised tensively.

Pemberton in the northwest section and north of
northeast. From the northwest section milk is ship
rail to Philadelphia (25 miles) or is sold to creamerie
In 1919 the average price received was 8 cents a quart
furnished by the buyer. Herds in this section aver
and 20 head. Grade Holsteins are the common bree

From the Lakewood region, known as the "shore
milk goes to the shore resorts, in most instances dire
sumer, so that producers receive nearly twice as much
Pemberton and Vincentown districts. This seeming
large measure offset by the lighter and more sandy c
soil, necessitating the purchase of part of the dairy f
the Pemberton district practically all the feed is grow
the soils being more productive. Farm practices in
much the same, except that north of Lakewood less
more potatoes and truck crops are grown and the yie
better. The truck crops are chiefly tomatoes, cabba
beets; they are marketed at the shore resorts. Po
through the county exchange or local dealers.

In the northern part of the area very large areas
have been cleared, diked, drained, and planted to cr
production of cranberries is perhaps the most import
industry of the Chatsworth area. Several companies
have long "chains" of bogs, large areas being so use
Lisbon, near Hanover Furnace, Hampton Gate, Ats
Batsto, Martha, Penn Place, Stafford Forge, and D

In the Chatsworth area there is a close relationship between the character of the soils and the agricultural development. This is of course to be expected in a region which has been open to settlement for 300 years. The relatively heavy and well-drained soils of the northwestern and northeastern sections of the area are mostly cleared, and the agricultural practices followed on these are of the modern type, while the lighter, more sandy, rather unproductive soils of the central and southern parts very largely have been left in forest. This selective differentiation of soils by the farmers is shown even in the numerous small clearings which have been made in the wooded sections. Although most of these clearings, for one reason or another, have been abandoned, their soils are almost invariably of a better type than those of the surrounding uncleared land.

There is also a marked tendency among the farmers of the Chatsworth area to recognize that certain soils are best adapted to the production of certain crops. For example, in the northeastern part of the area vegetables are grown on the lighter sandy soils, and corn, potatoes, and grass on the heavier lands. It is not unusual to find, on the same farm and in the same field, corn on the more sandy part of a field and potatoes on heavier land, the contact line of the two crops marking a distinct boundary between two soil types. Even in the selection of the variety of potatoes soil texture is frequently one of the first considerations. The American Giant does better on the more sandy soils and is grown almost exclusively on sandy soil types, while on the heavier soils round varieties, such as Cobbler and Mills Prize, are more extensively grown.

Corn, the principal cereal crop, is grown on practically every farm in the area. On the better farms the seed bed is well prepared. The seed is planted, with a corn planter or by hand, the latter part of May or early in June. The crop is intensively cultivated with weeders and cultivators. Fertilizers, when used, are applied at the rate of about 800 pounds per acre. The mixtures used run close to a 3-8-10[4] mixture.

The hay crop is largely timothy, red clover, and alsike clover seeded together. Mixed hay is harvested the first year, with clover predominating, but in the second and third years the crop is mostly timothy. Seeding is done late in August, on land from which a crop of potatoes or rye has been harvested, and cutting begins in June and October. Salt marsh hay is cut from the Tidal marsh in summer, or, if the season is wet and the meadows are flooded, the cutting is delayed until the ground is frozen in winter. Only one cutting is made each year. The alfalfa acreage is small, but it is increasing yearly. Three cuttings are made and occasionally a fourth. The well-drained heavier soils, when limed and inoculated, give good yields. More attention should be given to this crop, especially in those sections where dairying is important.

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[4] Percentages, respectively, of nitrogen, phosphoric acid, and potash. The mixtures quoted are those used before 1917. War conditions eliminated the potash entirely or reduced it to 1 or 2 per cent.

Rye and wheat are important grain crops, and usually follow corn in a 4-year rotation of corn, rye, or wheat, followed by grass. When potatoes are grown, the grains are usually planted as a cover crop in the fall after the potatoes are dug to be plowed under the following spring. Normally the acreage of rye greatly exceeds that of wheat. Rye straw brings a much higher price than that of wheat, and rye can be grown on a wider range of soil types than wheat, being specially adapted to sandy soils. The great demand for wheat and the high prices during the World War temporarily stimulated the production of wheat. The oats crop is of little importance in the Chatsworth area.

Potatoes are frequently grown year after year in the same field, following a cover crop of rye or wheat, or a mixture of one of these with crimson clover. The mixed seeding apparently gives better results, as the clover adds nitrogen; and possibly the tender clover plants are protected somewhat from winterkilling by the rye or wheat. This practice of mixed seeding of cover crops is rather unusual, but in many instances the potato yields appear to be increasing where it is used. Most of the potato seed comes from Maine. Potatoes are planted early in April, using a machine planter. A 4-8-10 fertilizer mixture is commonly applied at the time of planting at the rate of about 1,000 to 1,500 pounds per acre. Some farmers use more, others less. The shortage of potash brought on by the war necessarily lessened the applications of this element. Production, however, has not been seriously affected, and the question has been

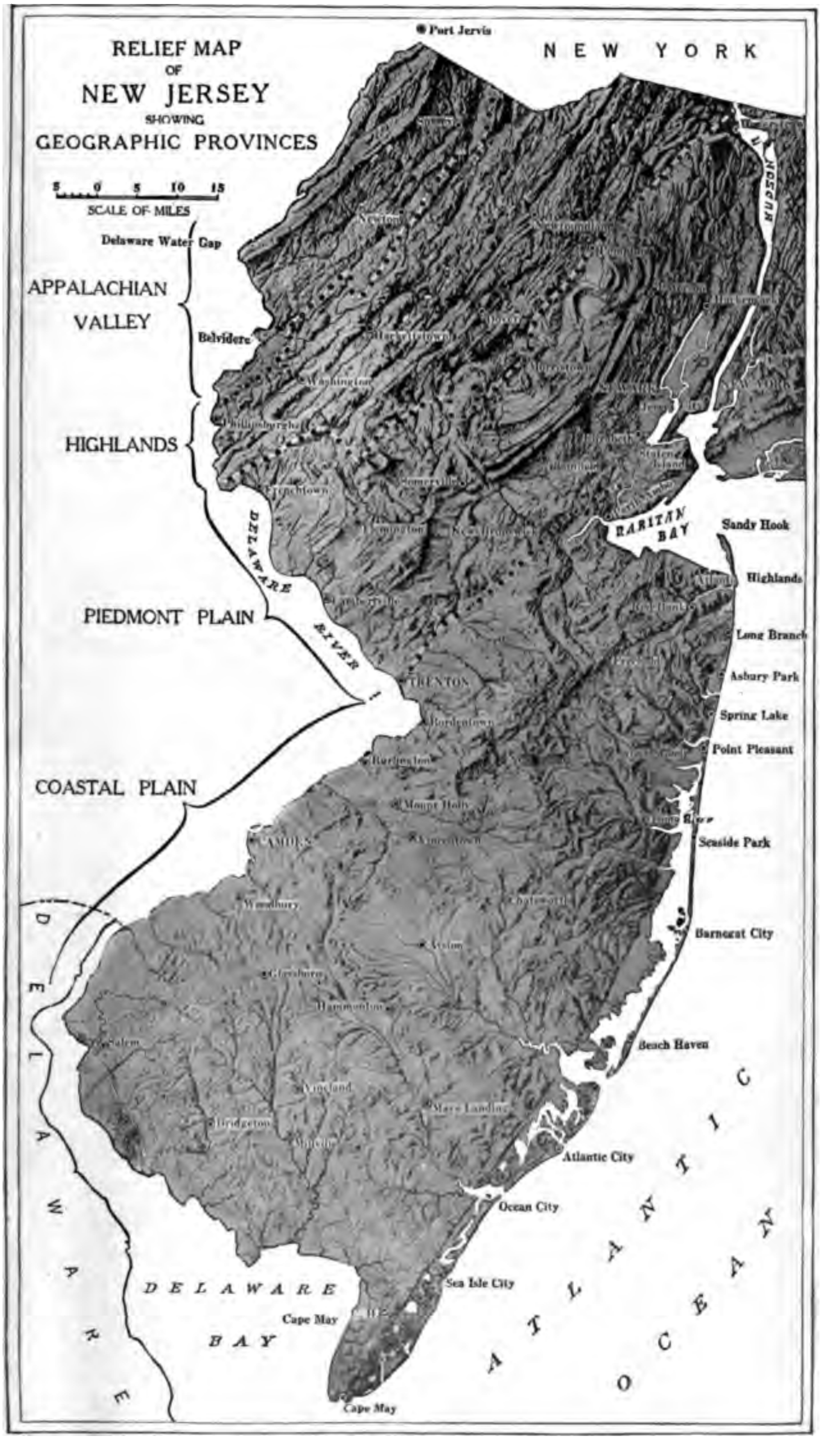
eppers are set out in rows about 3 feet apart as soon as danger
m frost has passed. They are fertilized somewhat heavier than
atoes, the average application in normal times being about 1,000
nds per acre. Careful attention is given to cultivation during
wth, and the fields are picked over several times each season.
crop is shipped either in barrels or hampers. The principal vari-
s are Ruby King, Cheese, Bull Nose, White Cap, and Chinese
nt.

ruit production in the Chatsworth area is limited chiefly to
ches, but some apples and pears also are grown. There are excel-
t opportunities in the area, however, for fruit growing, especially
peach production on the well-drained sandy soils. At present
re are a few commercial orchards in the area where modern meth-
are understood and practiced. Among the peaches the Elberta
he favorite variety, and some Carman, Belle, and Champion are
wn. Peaches usually are shipped to New York packed in Georgia
riers or baskets. The production of apples and pears is not im-
tant.

he berry crops include blackberries, raspberries, dewberries, and
wberries, grown chiefly in the southwestern part of the area. The
ps are heavily fertilized, and under careful attention excellent
lds are obtained. The berries are placed in quart or pint boxes,
ked in crates, and shipped to outside markets, usually New York
Philadelphia.

he cranberry industry is of great importance. According to the
sus of 1920 there were grown in 1919 in Atlantic, Ocean, and Bur-
gton Counties, 7,172,719 quarts of cranberries on 6,011 acres of
g. The acreage and production increased in Atlantic County in
last 10 years, and decreased in Ocean and Burlington Counties.
rlington County in 1919 produced about 73 per cent more cran-
ries than Ocean and Atlantic Counties combined. Practically all
producing cranberry acreage in Burlington County lies within the
ndaries of the Chatsworth area.

Bogs are laid out in low swampy areas by clearing off the forest
d building dikes, drainage ditches, and flood gates. Damage from
st and winterkilling is prevented by flooding the bogs during freez-
weather. Flooding usually begins late in November, and the
nts remain under water until early spring. The larger growers
intain reserve supplies of water in large reservoirs ready for instant
. Streams are frequently diverted from their courses and ditches
g at considerable expense in order to maintain an adequate supply.
og is certain to prove unsuccessful and the plants will be injured
frost or winterkilled if sufficient water is not obtainable when
ded. Many failures in the cranberry industry are due to the lack
sufficient supplies of water for flooding the bogs. The flow from
ervoirs is regulated by systems of ditches, dikes, and flood gates.



GEOGRAPHIC PROVINCES OF NEW JERSEY.

t is strongly acid, and they appear to grow best on soil composed ;ely of peaty material and sand, such as is found in many places)r near areas mapped as Swamp, St. Johns sand, and Leon sand. 'arms of the Chatsworth area are in general only moderately well ipped. In sections where certain crops have been specialized, :or example, in the vicinity of Pemberton and northeast of Lake- ›d, more modern labor-saving implements are used and less hand)r is performed. Only a small number of tractors are used in the ι. Poultry farms surrounding Lakewood are generally well ipped.

ood methods of cultivation are followed throughout the area, ›cially where the land is farmed intensively, as in growing truck. ;ivations usually follow each rain, at first relatively deep and)ming more shallow as the crop matures.

onsiderable attention is given to the rotation of crops, especially he general farms and dairy farms. The common rotations cover ·year or 5-year period, and consist of corn, followed by rye and ι by grass, the last-named occupying the land 2 or 3 years. ɜre potatoes are grown the rotation is corn 1 year, potatoes 1 to ars, or rye 1 year followed by grass 1 to 3 years. Frequently a that has been in corn is cropped in part to potatoes and in part ye, the potatoes occupying the heavier soil. This forms an elastic tion well adapted to the needs of the farm and soil. Occasionally he lighter sandy soils cowpeas follow the rye harvest. These are ed under the same fall and the field is again seeded to rye. ›n wheat is grown it replaces rye in a 4-year rotation consisting orn 1 year, wheat (sown with grass) 1 year, and grass 2 years. ›n potatoes are grown for several years continuously on the same , careful attention is given to cover crops. These consist usually ye, wheat, or crimson clover, or a combination of rye or wheat . clover. The seeding is done late in August and the crop plowed ɜr the following spring. Where the truck crops are extensively rn, less attention is paid to rotations.

ɜrtilizers are almost universally used. Stable manure is usually ied to corn ground, and commercial mixtures are used on rye, ıtoes, and corn. Both manure and fertilizers are extensively l where truck crops are grown. Potatoes receive from about)0 to 1,600 pounds of commercial fertilizer per acre during normal ɜs, the mixture analyzing 4–8–10. Corn receives from 300 to 400 nds of a cheaper mixture, analyzing about 2–8–7. From 10 to ons of stable manure may be applied instead of the commercial ilizer. Rye receives much the same treatment, except when fol- ing potatoes, tomatoes, or other truck crops, in which case it is ly fertilized. Applications to truck crops vary within wide limits, ɜnding upon soil conditions and the crop grown. In 1909 the

In Ocean County 79.8 per cent of the farms were operated by owners and 14.7 per cent by tenants in 1900. In 1920 owners were operating 86 per cent of the farms. In Burlington County, between 1900 and 1920, the farms operated by owners increased from 59.2 per cent to 68.9 per cent, and in Atlantic County, in 1920, 91.7 per cent of the farms were operated by owners, as compared with 77.7 per cent in 1900. Various systems of renting are practiced throughout the area. Cash rents range between $2 and $10 per acre, depending upon soil, market conditions, and the crops grown. Share rents are usually on the basis of equal shares, the tenants bearing half the expenses and receiving half the crops.

The prevalence of mosquitoes during the summer months throughout practically all the Chatsworth area tends to retard agricultural development. It is believed that steps for their extermination, which could be accomplished at a relatively low cost in proportion to the probable resultant increase in land values, should be taken without further delay.

The value of farm land varies widely in different parts of the area. Prices to a large extent depend upon soil conditions, agricultural development, and location. The highest priced land in the area is found north and southeast of Lakewood, in the vicinity of Allenwood and Manasquan, where improved land sells for as much as $200 an acre. The nearness of these farms to Lakewood and the shore resorts and the fact that the soils are among the best in the area, account for the high price. Between Lakewood and Toms River improved farms with equipment, generally for poultry raising, bring from $75 to $250 an acre. Their value depends more on improvements suitable for poultry raising and upon location with respect to market than upon soil conditions. Around Pemberton $125 an acre is the prevailing price for improved land. Uncleared land sells for $3.50 to $20 an acre, depending largely upon location and character of the soil. The average price for such land is probably about $7.50 an acre.

SOILS.[7]

The Chatsworth area lies wholly within the Coastal Plain. The materials of this physiographic province in New Jersey consist mainly of unconsolidated beds of sand, gravel, clay, and greensand marl, which were deposited in the sea under varying conditions of depth, agitation of water, and distance from shore. Since the elevation of this part of the ocean floor, streams, winds, and other agencies of erosion have removed some of the materials, shifted and redeposited others, and more or less modified and rearranged the original marine deposits. Undoubtedly there has been considerable removal by leaching of the soluble substances formed through the weathering and decay of the mineral particles in the soil. There is no considerable amount of lime carbonate in any of these soils, at least none of them effervesce with hydrochloric acid.

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[7] The soils of the Chatsworth area join well with the soils of the Millville area, with the exception that some areas of the Sassafras sand in the Millville area abut upon the Lakewood sand, shallow phase, in the Chatsworth area. In the Chatsworth area it was decided to map some of those areas having a shallow white surface soil as the shallow phase of the Lakewood, regardless of the fact that the same soil had been mapped previously as Sassafras sand in the Millville area.

The soils of the Chatsworth area join up with those of the Camden area in all essentials, except that the areas which were mapped as Hyde loamy sand in the Camden area have been mapped simply as Swamp in the Chatsworth area, the latter classification being considered the better because of the wide variation in the character of the material and the very wet, swampy nature of these lowland areas.

The surface parts of these modified and shifted materials, with the addition of varying amounts of organic matter, constitute the present soils of the Chatsworth area. Under the influence of the processes of weathering and the wide variations in the drainage, due to topographic differences, a relatively large number of soil types have been developed within a small area, and with such degrees of gradation that it is not everywhere easy to determine accurately their limits.[a]

The upland soils are dominantly sandy, highly quartzose, with low content of mineral particles other than quartz, except where greensand particles are present. Much of the well-drained sand is a clean white to light grayish color; but in the low wet areas dark-colored vegetable matter has accumulated in the soil in varying amounts, ranging in portions of the areas of Swamp as high as that of peat, which contains 90 per cent or more of partially decomposed plant remains. The marshes, swamps, and wet soils include much material in which processes of weathering, as oxidation and excessive leaching have been retarded, owing to the saturated condition. In other words, those natural processes which act toward the development of mature or normal upland soils have here been retarded or inhibited of the subsoil and substratum insures good underdrainage and ready permeability by plant roots. The Sassafras soils are mellow and easily worked. The types of the Sassafras series mapped in the Chatsworth area range from loam to coarse sand.

The types of the Collington series are distinguished by the brown or grayish-brown color of the surface soils, the reddish-yellow or orange color of the subsoil, and the presence of varying amounts of greensand marl in the soil or subsoil, or both. The Collington soils usually have a decided olive-green or greenish-brown tinge in the subsoil, and, in places, in the soil, and a characteristic greasy texture. Except for the very heavy types, the Collington soils are mellow and easily worked. This series has a level to very gently sloping topography and the drainage is good. The material of the heavier types is often of a strong green color and stiff structure, but this very green material consists mainly of the unweathered parent beds. Four types of the series are mapped in this area.

The Shrewsbury soils are closely associated with the Collington soils, occupying lower positions or flat areas where the drainage is imperfect. They are characterized by the brown or slightly grayish-brown color of the surface soils, and the mottled, greenish, yellowish, and reddish color of the subsoil. Glauconite (greensand marl) is present in varying quantities. The Shrewsbury sandy loam is the only type recognized in the Chatsworth area.

The types of the Keansburg series have black surface soils and a mottled, greenish, bluish, grayish, and yellowish subsoil. Their drainage is imperfect, rather poorer than that of the Shrewsbury series. The Keansburg soils bear the same relation to the Collington soils as the Portsmouth soils do to the Sassafras and Norfolk soils; that is, they are of the same derivation but have developed under conditions of poor drainage. The Keansburg loam is the only type mapped in this area.

The Norfolk soils are closely associated with those of the Sassafras series. They are distinguished by their grayish to light-brown surface soils and pale-yellow to yellow, friable subsoils. The Norfolk fine sand and an imperfectly drained phase of the Norfolk sandy loam have been mapped in this area.

The surface soils of types of the Lakewood series are white and the subsoil is orange or orange yellow. The organic content of these soils is very low, and they are composed very largely of quartz sand. The drainage is usually excessive, the topography level to hummocky, and the productivity low. The sand, with a shallow phase, the fine sand, and a deep phase of the sandy loam have been mapped here.

The types of the St. Johns series are characterized by the dark-gray or black color of the surface soil, the coffee-brown to dark-brown color of a compact or "hardpan" layer beneath, and the whitish, grayish, brownish, or mottled color of the deep subsoil. The "hardpan" layer shows a concentration of organic matter and to some extent of iron. The drainage is imperfect. These soils occupy depressions and lower situations. The sand is the only type mapped here.

The types of the Portsmouth series are poorly drained. The surface soils are similar to those of the St. Johns series, but the subsoil is white or mottled white, gray, and pale yellow. There is no hardpan layer, but the subsoil is saturated. The Portsmouth soils occur in the lower situations, without adequate drainage outlets, adjacent to or near areas of Sassafras or Norfolk soils. The sandy loam and loam have been mapped in this area.

The types of the Scranton series have black surface soils underlain by a pale-yellow subsoil, mottled in places with gray. Their drainage is better developed than that of the St. Johns or Portsmouth series. Frequently the Scranton soils occupy intermediate positions between these imperfectly drained soils and the well-drained soils of the Sassafras, Norfolk, and Lakewood series. The sandy loam is the only Scranton type mapped in the Chatsworth area.

The types of the Leon series have white or light-gray surface soils overlying a white subsoil with a coffee-brown "hardpan" layer, like that of the St. Johns, occurring at variable depths. This hardpan material passes down into light-brown, orange, or yellow, looser material. The Leon soils of the Chatsworth area differ from the typical Leon soils in other parts of the Coastal Plain in that the material below the hardpan layer is not so frequently dark colored, being generally orange or yellow. These soils occupy flats and depressions where the drainage is imperfect. They are associated with the

In the following pages the various soils are described in detail. Their distribution is shown on the accompanying soil map.

The names and the actual and relative extent of the soils mapped are given in the table below.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Lakewood sand	173,248	26.9	Sassafras loam	5,120	.7
Shallow phase	31,808		Collington fine sandy loam	5,056	.7
Sassafras sand	116,992	15.4	Norfolk fine sand	4,992	.7
Flat phase	640		Sassafras loamy sand	4,352	.6
Swamp	114,624	15.0	Flat phase	512	
St. Johns sand	60,800	7.9	Keansburg loam	3,968	.5
Sassafras sandy loam	29,184	......	Scranton sandy loam	3,968	.5
Deep phase	23,488	7.0	Shrewsbury sandy loam	3,776	.5
Flat phase	256	......	Freneau loam	3,136	.4
Sassafras gravelly sandy loam	50,816	6.6	Norfolk sandy loam, imperfectly drained phase	3,136	.4
Tidal marsh	48,576	6.3	Collington sand	1,920	.2
Lakewood sandy loam, deep phase	30,912	4.0	Collington sandy loam, deep phase.	1,792	.2
Sassafras fine sand	8,448	1.1	Portsmouth loam	1,664	.2
Coastal beach	7,680	1.0	Sassafras coarse sand	576	.1
Sassafras fine sandy loam	7,296	.9	Collington loam	128	.1
Leon sand	5,504	.7			
Lakewood fine sand	5,312	.7			
Portsmouth sandy loam	5,120	.7	Total	764,800	......

SASSAFRAS GRAVELLY SANDY LOAM.

In its typical development the Sassafras gravelly sandy loam is a brownish-gray gravelly sandy loam or loamy sand, which passes within a few inches into reddish-yellow gravelly sandy loam, forming the lower part of the soil and upper part of the subsoil. This grades into a gravelly sandy loam or gravelly sandy clay, in which the gravel and sand are coarser and below depths of 24 to 30 inches into still coarser material, consisting of a mixture of gravel and sand or coarse sand and sand. The gravel throughout the profile consists of rounded, waterworn quartz fragments.

This type is quite variable in texture. In many places in wooded areas the surface soil to shallow depths is gray to nearly white, approaching in appearance the Lakewood gravelly sandy loam. Below depths of 2 to 4 inches, however, the color is brownish gray, light brown or yellowish brown, and like the typical Sassafras. Much of this type as mapped in the vicinity of Barnegat Park, Elwood, Lacey, Forked River, and Cedar Grove has these characteristics. These areas would have been classified with some other series than the Sassafras, but for the fact that the white layer is very shallow, and that the material below has the Sassafras characteristics. In places there are areas mapped with the Sassafras in which the surface soil is yellowish brown or even reddish brown.

ion of the farm buildings, local topography, and condition of the l. Farther south and a few miles west of the coast forested land ı be bought as low as $10 to $15 an acre. Land values, however, r the area north and west of Toms River are depreciated at the sent time by the presence throughout the spring and summer nths and even late into the fall of numerous salt-marsh and fresh- rsh mosquitoes. Until some provision is made for the elimination ontrol of these pests, much of this land may remain undeveloped some time.

he material of this type is used extensively for road construction, gravel having just sufficient natural binding or clayey material orm a good road bed. The main highways of the area are at sent constructed of this material, and pits from which it is obtained numerous, as the map shows.

he productiveness of this soil can be increased by increasing the tent of vegetable matter. This can be accomplished by growing ver, peas, and other humus-supplying crops in the rotations. mmercial fertilizers and manure give marked results in increased lds.

SASSAFRAS COARSE SAND.

The typical Sassafras coarse sand is a brownish-gray or light-brown arse sand, about 6 to 8 inches deep, overlying yellow or reddish- llow gravelly coarse sand. In wooded areas the surface soil is ownish gray to gray, in cultivated fields light brown.

This type occurs mainly on gentle slopes, where the drainage is od to excessive. It is not extensive and not important agricul- ally. It is held at prices ranging from $10 an acre upward depend- chiefly on the desirability of the location.

Heavy applications of fertilizer or manure are necessary for the duction of good crops. The cost of production on such a coarse- tured soil is so high that there is considerable doubt whether it be farmed profitably under present economic conditions. For tain crops, such as blackberries, dewberries, and asparagus, it may possible to use favorably located areas with profit. Generally h land can best be used for forestry.

SASSAFRAS SAND.

Most of the Sassafras sand in this area consists of a layer of gray whitish sand, about an inch thick, underlain by brownish-gray nd, which at a depth of 5 to 8 inches passes into orange or reddish- llow slightly loamy sand subsoil. There is not much variation in e subsoil, except locally where in the lower part it is yellower and s loamy or redder and more loamy. In places there a is gravel or arse sand stratum between the depths of 20 and 36 inches.

ımbia. Some peaches also are produced. Yields in general are
ıewhat lower than on the heavier Sassafras types, and more or-
ic matter and fertilization are required for good yields. This soil
onds readily to liberal applications of commercial fertilizers, but
effects soon disappear. Cowpeas, clover, and rye are crops that
be advantageously grown to build up the humus content of
soil.

he forest growth is far superior to that on the Lakewood sand or
Johns sand. Various species of oaks predominate, with some
e and scrub oak. When such forested areas are protected from
and systematically thinned excellent stands of oak and pine
ow.

his type when in forest can be bought at the present time for
ut $15 to $25 an acre; sometimes for less. Cleared land brings
n $75 to $100 an acre, depending upon location, character of im-
vements, and state of productiveness.

assafras sand, flat phase.—The Sassafras sand, flat phase, consists
light-brown to brown sand passing at 6 to 8 inches into an orange,
dish-yellow, or yellow sand, which usually passes into pale-yellow,
sand in the lower part of the 3-foot section. In places a gravel
ıtum is present at depths of 24 to 36 inches. Small areas of Sas-
as sandy loam, loamy sand, and sand have been included on the
p, owing to their small extent.

his phase is associated with the better drained Sassafras types
ıg Barnegat Bay. It occupies flats in which the drainage is not
rywhere adequate and the lower subsoil is generally wet. A con-
erable part of it is cleared and used for berries and truck crops.
awberries are an important crop. Liberal applications of fertilizers
manure are required for the production of best yields.

SASSAFRAS LOAMY SAND.

he typical Sassafras loamy sand is a grayish-brown or light-brown
my sand, about 6 to 8 inches deep, overlying reddish-yellow loamy
ıd, the lower part of which is less loamy, coarser textured, and in
ne places more yellow. Gravel is present locally in the subsoil,
l here and there in the surface soil. In forested areas a thin layer
the surface soil in places is brownish gray and in spots almost
ite.

he Sassafras loamy sand occurs in comparatively small bodies
lely distributed throughout the area, being most abundant in the
inity of West Creek, south of Tuckerton, and around Lakewood.
ny areas occur upon flats in higher situations and others upon
tly undulating slopes. The drainage is well established.

ome of this type is cleared and used for the production of late
k crops, especially in the northeastern part of the area in the

required in order to obtain good yields of most crops. The soil d be improved by growing cowpeas and clover or by plowing er a crop of rye or other humus-supplying vegetation.

SASSAFRAS SANDY LOAM.

he surface soil of the Sassafras sandy loam in cultivated fields ists of light-brown to brown loamy sand or sandy loam, about 6 inches deep, grading into yellow or reddish-yellow loamy sand ndy loam, which at about 12 to 15 inches passes into yellow or lish-yellow sandy clay, and this, in turn, into reddish-yellow ly clay, which may contain gravel or coarser sand, or both, in lower part of the profile. The lower subsoil is nearly always e sandy and contains less fine material than the stratum above. rested areas the surface soil is usually grayish brown or light vn in color. In places the soil profile consists of grayish-brown ght-brown sand or loamy sand, passing at 2 or 3 inches into yel- or yellowish-brown loamy sand, which grades downward into ish-yellow sandy loam and then, at about 12 to 15 inches, into ish-yellow friable sandy clay. In such areas a reddish-yellow y sand or loamy coarse sand occurs at 22 to 26 inches.

here are included within this type, as mapped, areas of Sassafras , as south of Aserdaten, and also some areas of Sassafras gravelly ly loam, coarse sandy loam, loamy sand, and sand. Some areas of nton sandy loam, consisting of black sandy loam overlying red- -yellow sandy loam, locally mottled gray and yellow in the lower oil, are also included.

e Sassafras sandy loam is an important soil, especially in the heastern part of the area north of Lakewood. It occurs quite nsively, however, in all parts of the area, except in the central . It generally occupies the level situations associated with the afras loam, gravelly sandy loam, loamy sand, and sand. In map- this type some strips of material approximating sand or loamy in texture were included, the gradation between the soils being that arbitrary boundaries were necessary in some places. The graphy is level to gently rolling, and the drainage is good.

uch of this type is cleared and farmed, particularly in the north- art of the survey. Here it is a very productive soil. It is han- much the same as the Sassafras gravelly sandy loam. It is cially adapted to potatoes, being excelled for this crop only by eavier Sassafras loam. It is also extensively used for late truck general farm crops. Dairying and general farming are practiced this type around Camp Dix.

ks predominate in forested areas, with a scattering of pine. h of the virgin forest growth has been destroyed by repeated fires, the growth is generally stunted. With protection, however, the produces a fine growth of oak.

f this type is to be successfully cultivated, however, the turning
ler of humus-supplying crops or manure is essential. Commer-
l fertilizers increase the yields of all crops, undoubtedly giving the
t results in those areas where the soil has not been depleted of
anic matter.

SASSAFRAS FINE SANDY LOAM.

he Sassafras fine sandy loam consists of a brown to slightly dark
wn loamy fine sand or fine sandy loam, 8 to 10 inches deep, under-
l by yellow loamy fine sand or fine sandy loam, which passes
ckly into reddish-yellow, friable, heavy fine sandy loam or fine
dy clay, and this passes at about 24 inches into reddish-yellow
range-colored friable sandy clay. In places, as about 2 miles
thwest of Glendola, the lower subsoil is a reddish-yellow fine sand
oamy fine sand.

his soil is less extensive than some of the other Sassafras types,
large bodies of it occur north of Bennetts Mills, west of Farm-
dale, southeast of Maxim, near Indian Mills, and south of Taber-
le. The surface is level to rolling and the drainage is good.

robably 40 per cent of it is cleared and farmed. The native
ber consists of various species of oaks, with chestnut, sassafras,
h, hickory, and a scattering of pine. When protected from fire
ellent stands of timber are obtained.

he tilled area of this type is utilized principally for the general
n crops of the region in conjunction with late truck crops. Dairy-
and fruit growing also are of some importance. This is an espe-
ly good potato soil, surpassed, probably, only by the Sassafras
n. Yields of 200 bushels per acre are not uncommon.

he type is naturally a good soil, but in order to keep it produc-
winter cover crops and legumes should be included in the rota-
s and plowed under as a source of organic matter. Liming has
ved beneficial on this soil as well as on the other important types
the Sassafras series through the New Jersey, Delaware, and the
sapeake Bay region. Manure or commercial fertilizer is necessary
the best yields.

SASSAFRAS LOAM.

he surface soil of the typical Sassafras loam consists of a light-
wn to brown loam, 8 or 10 inches deep; the subsurface or upper
soil consists of reddish-yellow friable loam extending to a depth
about 18 inches, and the middle subsoil of dull-red to yellowish-
friable sandy clay containing some fine gravel and sand. In
ces, as at Camp Dix, the type consists of brown friable loam,
lerlain at 6 or 8 inches by reddish-yellow loam which is redder
l more sandy in the lower part of the 3-foot section. In other
ces the subsoil is very gravelly. In forested areas the light-brown

icentown, where a large proportion of it is cleared and farmed, and
other small areas north of Fort Plains. It occupies level to
tly rolling country and is well drained. The native forest growth
hiefly pine and oak, the latter predominating.

When farmed this soil is managed in much the same way as the
safras sand and has the same crop adaptations. Truck crops,
h as sweet potatoes, tomatoes, muskmelons, watermelons, and
pers are the principal crops. The productiveness of the land
ld be improved by the addition of stable manure and the growing
lover and cowpeas. It is naturally low in organic matter. Fer-
zers are necessary in rather heavy applications for the production
good yields of most crops.

COLLINGTON SANDY LOAM, DEEP PHASE.

The Collington sandy loam as mapped in this area is a deep phase
the type. It consists of light-brown or brownish-gray sand or
my sand, underlain at 6 to 8 inches by reddish-yellow sand contain-
some dark-green particles, and grading at about 24 to 30 inches
greenish-yellow sandy clay. Glauconite or greensand marl,
ch accounts for the greenish tinge, occurs in varying quantities
oughout the 3-foot section. It is particularly prominent in the
dy clay subsoil, but generally is not conspicuous above the lower
soil. In places the heavy sandy clay layer is encountered at
ut 14 inches; in other places below 30 inches, the average depth
ng about 18 to 20 inches. Some small, unimportant areas, in
ch the material is fine in texture—in reality the Collington fine
dy loam, deep phase—are included with this soil.

This is not an extensive soil. It occurs chiefly in the northwestern
northeastern parts of the area, in the vicinity of Pemberton,
th of Smithville, 1½ miles north of Fort Plains, and northwest of
st Farms. The surface is gently rolling, and the drainage is good.

ractically all this soil is cleared and farmed. It is especially
pted to truck crops, such as tomatoes, sweet potatoes, musk-
ons, peppers, and watermelons, and to potatoes to some extent.
farm practice it receives much the same treatment as the Col-
gton fine sandy loam with which it is associated.

The plowing under of more vegetable matter, which may be sup-
ed by crops of cowpeas, clover, or rye, would improve the pro-
ctivity of this soil. Manure or fertilizer is necessary for good
lds.

COLLINGTON FINE SANDY LOAM.

To a depth of about 8 or 10 inches the Collington fine sandy loam
nsists of a brown loamy fine sand to fine sandy loam with a green-
cast. This is underlain by reddish-yellow fine sandy loam to

COLLINGTON LOAM.

Typically the Collington loam consists of a brown to rather dark own mellow loam, about 8 to 10 inches deep, underlain by reddish-own heavy loam to clay loam containing enough greensand terial to impart in places a greenish color.

This type is mapped only at Smithville and southwest of Ewansle. It occupies flat level positions, but the drainage is good. All type is cleared and farmed. It is handled in much the same nner as the Collington fine sandy loam, with which it is closely ociated. Yields are somewhat larger on this type than on the hter sandy loam of the series. The general farm crops, such as n, small grain, timothy and clover, and potatoes, are grown.

SHREWSBURY SANDY LOAM.

The Shrewsbury sandy loam consists of a brown or grayish-brown dy loam, about 8 to 10 inches deep, underlain by mottled green, yellow, bluish-gray, and reddish-yellow sandy clay, which at out 20 to 24 inches passes into heavier sandy clay of mottled enish, yellowish, and reddish colors. In places the surface soil a dark-brown to black loam, representing inclusions of Keansburg m. There are also included within this type areas of Shrewsbury m and fine sandy loam.

An area 1 mile northeast of Vincentown consists of brownish-gray gray heavy sandy loam to loam, underlain at about 8 inches by ttled bluish-gray and yellow silty clay loam to sandy clay loam, at about 15 inches by mottled bluish-green and yellow sandy y loam to silty clay, which passes at about 20 to 24 inches into a en sand, loamy sand, or sandy loam showing some reddish motg. An area one-half mile southeast of Vincentown consists of wn sandy loam about 10 inches deep, overlying yellow sandy y to about 15 inches, with mottlings of bluish gray below this, the er subsoil consisting of mottled reddish-brown and bluish-gray dy clay which passes at about 30 inches into a reddish-yellow, low, and gray sand.

This type is not extensive, occurring only in the northwestern part he area. Most of it is under cultivation. There are large developnts in the vicinity of Vincentown and Pemberton, south of Birmham, and near Beaverville. This soil occupies low-lying flat areas joining the Collington soils on the higher level and the Keansburg ils in the lower depressions. The drainage is imperfect but not so or as on the Keansburg loam.

When artificially drained, this type produces especially heavy yields corn, timothy and clover hay, wheat, rye, and late truck, particurly tomatoes. Farmers report yields of 80 bushels of corn per acre, and 1½ to 2 tons of timothy and clover hay. Dairying is quit sively practiced on this type east of Vincentown. The h mostly grade Holstein cattle, and average from 15 to 20 hea soil does not seem especially well adapted to potatoes. It i warming up in the spring, and the drainage at this season is in Fair yields are obtained, however, especially during dry seas

Land of this type sells at the present time for about $75 an acre when drained and cultivated.

This soil requires occasional applications of lime, and als cial drainage, either with open ditches or underground drain best results. Tile drains give the most satisfactory results.

The following table gives the results of mechanical ana samples of the soil and subsoil of the Shrewsbury sandy loan

Mechanical analyses of Shrewsbury sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
170833	Soil	6.1	18.9	7.8	23.2	13.7	19.2
170834	Subsoil	1.0	2.2	.1	24.2	37.5	22.6

KEANSBURG LOAM.

The Keansburg loam has a very dark brown to black loam soil, 8 to 10 inches deep and rich in organic matter. underlain by gray silty clay to sandy clay, which grades bel greenish or bluish-gray silty clay to sandy clay showing some mottling. At about 20 inches this overlies green silty clay t clay with yellow and reddish-brown mottling. In places, as n this reason it is better adapted to the production of the general m crops than to trucking. Vegetables are said to mature 10 days 2 weeks later than on the better drained soils. This type when ined is well suited to corn. Yields of 80 to 100 bushels per acre obtained. Timothy and clover hay yields range from 1 to 1½ ns per acre.

The tillage methods practiced are practically the same as those ployed on the Sassafras loam, although the Keansburg loam is her restricted in the range of moisture conditions under which it n be plowed satisfactorily. Crops on this type do not receive as ch manure or commercial fertilizer as on many of the other soils. When drained, the Keansburg loam is one of the most productive neral farming soils of the area, and under proper management it is surpassed for the production of hay and corn. Liberal applications lime would probably give favorable results. Artificial drainage is ential, and tile drains should be used instead of open ditches. e lower, wetter areas, where drainage is impracticable, can be util- d to the best advantage as pasture land.

NORFOLK FINE SAND.

The Norfolk fine sand is a grayish-brown or brownish-gray loose e sand, 3 or 4 inches deep, underlain by yellow or pale-yellow fine nd. In places, especially in the lower situations, the subsoil is ghtly reddish or orange colored, approaching in color the character- ic Sassafras subsoil, but such areas are not typical. In low, flat as the lower subsoil shows some gray mottling and is quite moist. The Norfolk fine sand is not an extensive type, nor is it of great icultural importance. It is developed chiefly in a narrow belt ng south of the outcropping marl formations, although areas of it ur elsewhere in the survey. The largest tracts lie near Flyat and x Chase. This type occupies well-drained areas having a some- at hillocky or ridgy surface. The drainage is excessive in places, ecially in the higher situations. Only a small part of this type is ared.

The virgin forest consists chiefly of scrub oak and pine. Holly, untain laurel, and huckleberry form the principal undergrowth, h considerable wintergreen in lower situations. This soil is too t for best results with the general farm crops, but under careful nagement good results are obtained with vegetables. Sweet pota- s, peppers, early tomatoes, and muskmelons are the principal ps. Corn is grown to some extent, but it does not give as satis- tory results on this type as on the heavier soils.

This soil is naturally low in organic matter, and the plowing der of leguminous crops, such as peas or clover, together with the dition of stable manure, will increase its productiveness. Com-more. Locally the orange-yellow color of the subsoil passes into llow in the lower subsoil. In some places there is a faint reddish st to the yellowish subsoil. The subsoil in general is uniform in cture; in places it contains some gravel and coarse sand.

In some of the low, flat situations adjoining areas of St. Johns nd a thin layer of dark-brown to coffee-brown incipient hardpan encountered at depths of 10 or 12 inches. This passes at 14 to 16 hes into orange or reddish-yellow sand. Such areas as the latter resent a transition soil between the low, imperfectly drained Johns sand and the typical Lakewood sand on the higher situa- ns. The soil with the hardpan, such as is found about 2½ miles theast of Browns Mills, represents an inclusion of Leon sand.

As this type has been mapped there are small included areas of on sand, Lakewood sand, shallow phase, Norfolk sand, and Lucie sand. The last-named type consists of clean white sand a depth of 36 inches or more.

The Lakewood sand is the most extensive upland soil in the area. th Swamp and St. Johns sand it occupies most of the central part the area. It occurs in large bodies extending in every direction m the vicinity of Chatsworth to the coast, south to the Mullica er, and north to Lakehurst. There are large bodies also at wns Mills, north of Batsto, and southwest of Toms River. The face is typically rolling or slighty hummocky, but in places it is or nearly so. The drainage is usually excessive.

ery little of the type is cultivated, by far the greater part being ered with a forest growth, in which the trees are small and in ces scattered. This forest consists chiefly of pitch pine and scrub , with an undergrowth of huckleberry and other shrubs. In ny places the growth consists of a thick bushy growth, with but trees of any size.

he agricultural value of this soil is low, and much of it is owned the townships, the original owners having failed to pay taxes. es of large tracts have been recorded at prices ranging between and $4 an acre, the tracts including, usually, one or more areas swamp supporting a valuable growth of white cedar. In some ts of the State small fields and patches of Lakewood sand are ng used in the production of dewberries and blackberries and of aragus and other vegetables. Manures or fertilizers are necessary, d heavy applications must be used in order to obtain good yields. e soil is exceptionally low in organic matter, and this should be plied where areas of this soil are brought under cultivation.

Lakewood sand, shallow phase.—The Lakewood sand, shallow phase, sists of loose, white sand to a depth of about 4 to 6 inches, overng orange-colored or yellow sand. In places the surface soil is yish. Included within this phase are small areas of typical Lake-

sists chiefly of oak and pine. The virgin grow
better than that on the typical Lakewood sand, in
sized trees.

The soil is considered better farm land than th
but not as productive as the Sassafras sand. Ve
and berries are the crops that may be expectec
This soil, like the typical Lakewood sand, is ex
organic matter, especially in the first 6 inches.
quartzose and low in plant nutrients, as the very
quartz sands of the humid region characteristical
aid of stable manure or fertilizers, or both, the yield
By plowing under green vegetation, such as rye an
content can be built up, but some manure or fertili
for the production of good yields of these soil-imp
any other crops for that matter, and even after
been improved, manure or fertilizer still will be
ment must not be expected to be as lasting as on th
soils.

LAKEWOOD FINE SAND.

The Lakewood fine sand consists of 8 to 12 inches
overlying orange-colored, loose fine sand, which pa
yellow or pale-yellow fine sand. In some places,
lying areas, a rather compact layer of brownish san
pient hardpan is encountered at various depths.
sent inclusions of Leon fine sand where the soil i

Much of the Lakewood fine sand is cleared and under cultivation. e open nature of this soil allows cultivation at any time. The il is used mainly for truck crops, though to some extent for corn. e successful truck crops include lima beans, tomatoes, peppers, bbage, watermelons, muskmelons, beans, peas, and sweet corn. few potatoes also are grown. Ready markets for these products e found in near-by coast resorts.

This type is of considerably greater agricultural value than the kewood sand, approaching that of the Sassafras sand and fine nd. The fine texture causes it to hold moisture better, and applitions of commercial mixtures do not leach out quite so readily as m the coarser textured Lakewood sand. This soil, like the Lake- od sand, however, requires the addition of stable manure or other getable matter to maintain the proper supply of humus, and nure or fertilizer in liberal quantities is required for good yields. erhead irrigation probably would prove profitable in the produc- n of truck crops.

LAKEWOOD SANDY LOAM, DEEP PHASE.

The Lakewood sandy loam, deep phase, consists of about 4 to 8 hes of white sand, frequently a little grayish in the surface inch, ing to the organic matter present, underlain by yellow or orange- llow loamy sand passing at depths ranging from about 12 to 24 hes into reddish-yellow, orange-yellow, or yellow sandy loam to dy clay, which, in turn, passes abruptly into yellow friable sandy y at depths of about 30 inches.

In some of the lower situations a thin layer 2 or 3 inches thick of wnish sand of the nature of incipient hardpan is found here and re at depths of 12 to 14 inches. This layer passes abruptly into nge-colored to yellow loamy sand, sandy loam, or gravelly sandy m below. Such areas constitute Leon soil or a close approach to t soil, but the areas are small and unimportant and for that reason e not mapped separately. In many places the surface soil consists 12 to 14 inches of white sand containing considerable gravel, with nge or reddish-yellow heavy sandy loam beneath.

In many places, also, there are included areas of Lakewood gravelly dy loam. These are shown by gravel symbol. They consist of ctically the same kind of soil and subsoil as the Lakewood sandy m, deep phase, except for the presence of considerable quantities quartz pebbles an inch or less in diameter. This gravel is almost re white, differing in this respect from the gravel of the Sassafras avelly sandy loam, much of which has a distinct yellowish tinge.

An excavation was made on this type in the plains about 3½ miles rtheast of Cedar Bridge. This showed the following characteristics

Vith its humus-free white soil, land of this type in general can pos- s only a low degree of inherent productivity, but with some manu- treatment, as applications of manure or fertilizer, as an initial nulant to plant growth, it can be made to grow soil-improving ps, as rye or cowpeas, or possibly clover if heavily limed with nt lime, and in this manner the humus content of the soil can be reased and the land eventually brought up to a productive condi- n suitable to the production of some of the farm crops. Care prob- y should be taken not to plow up too much of the raw subsurface terial in any single year—not more than about 1 inch of the mate- l lying below the plow depth of the preceding year. Fertilizers or nure will be required for good yields.

ST. JOHNS SAND.

The typical St. Johns sand is a black sand about 7 inches deep, erlying white sand to a depth of about 16 inches. At this depth a rk-brown, compact layer of sand about 4 inches thick, having the aracter of incipient hardpan, is encountered, below which is found gy orange-yellow sand to a depth of 36 inches or more. The hard- n layer contains considerable organic matter and some iron. A nple of this layer analyzed 1.43 per cent organic matter and 0.20 r cent iron. The lower sand stratum is usually saturated with ter and flows slowly into excavations, resembling "quicksand" in s respect. A considerable proportion of coarse quartz fragments pears in the lower subsoil of some areas. The material from the face down is decidedly acid in reaction.

As mapped, the type shows some variation. In places the surface l is loamy, owing to the presence of organic matter, and is under- n at about 5 to 10 inches by brownish to grayish sand passing ruptly into white sand, below which the dark coffee-brown to rly black, rather compact sand is found at depths varying from 10 36 inches. In the lower depths of the compact stratum the soil omewhat looser and passes into yellow or orange-colored sand, with y to white sand or fine gravel and sand beneath. In places no itish material is present between the black surface soil and the wn hardpan layer.

There are included with the St. Johns sand, as mapped, small areas Scranton sandy loam and Portsmouth sand. In the former no dpan layer is encountered, and the subsoil is a yellow sandy clay. e Portsmouth sand consists of black sand or black mucky sand erlying whitish to gray sand, which is normally saturated with ter. There are also small areas of Leon sand and Swamp, which ve been included within this type on account of their small extent.

The St. Johns sand is an extensive soil. It occurs in large areas in e vicinity of Retreat, Magnolia, Hampton Park, Rockwood, and btained. Some small areas have been diked and are utilized as erry bogs.

e forest growth is thick and includes oaks of several species, e, gum, birch, and a few scattering pines. Wintergreen or tea- is abundant, and in places there is considerable holly and laurel. a, ferns, high-bush huckleberry, and a variety of moisture- g shrubs are common plants on the Portsmouth soils of New y.

en drained this soil has considerable agricultural possibilities. drains probably will give better all-round drainage results than ditches, but the latter have frequently been employed effectively aining this kind of land.

reclaiming this land liberal additions of lime, probably from 1 tons per acre of burnt lime or twice as much ground limestone d be applied. Manure or commercial fertilizer also will be needed oderate to fairly heavy additions in order to get best results any of the crops to which the soil is adapted.

PORTSMOUTH LOAM.

e Portsmouth loam is a black mucky loam, about 10 to 12 inches overlying whitish sandy loam to sandy clay, with some pale- w mottling in the deep subsoil. In some parts of the type, as been mapped, the soil is a black mucky loam with considerable 10 or 12 inches deep, while the subsoil is a white saturated sand, in exposed sections, as in ditch banks, caves and flows in the er of quicksand. There are some included small patches of St. loam, such as those about a mile northwest of Whitesville. the soil consists of a black loam, 6 to 10 inches deep, overlying sh or light-gray loamy sand to sandy loam, with a brown sandy an layer at about 20 inches. In places the hardpan layer occurs nearer the surface and grades down into yellowish or orange- ed sandy material.

is type is not extensive, and therefore of little agricultural impor- . It occupies low, depressed areas, frequently about the heads reams where drainage is imperfect. Most of it is still forested scrub pine and oak and a variety of moist-land shrubs. When ed and farmed good yields of timothy hay and corn are obtained. age is also grown to some extent on this soil.

is soil is naturally rich in organic matter, and when drained and ly limed it is likely to prove a good soil for strawberries, corn, , and late truck crops. It is said not to be particularly adapted tatoes. Strawberries, lettuce, and onions are successfully grown is type of soil in other regions.

SCRANTON SANDY LOAM.

The Scranton sandy loam consists of a black mucky lo
sandy loam, having a depth of 8 or 10 inches, underlain
orange-yellow sandy loam or friable sandy clay, becomin
with depth. The surface soil of this type is similar to
Portsmouth and St. Johns soils, while the subsoil close
the subsoil of the imperfectly drained phases of the Norf
places there is some gray and orange-yellow mottling
subsoil, which is usually moist.

This soil occupies flat, rather low situations having imp
age, as in the section near the shore of Barnegat Ba
important either in extent or agricultural use. Except a
shore, most of it is in forest. The native growth consist
of oaks, pine, cedar, maple, black gum, birch, smilax, a

This type could be greatly improved by underdrainag
eral applications of lime. It seems to be well adapted to
and good grass and corn crops are also obtained. Cabb
cauliflower, and a number of other vegetables are grow
soil in some of the southern trucking districts. Liberal
of manure or commercial fertilizer may be expected to
yields markedly.

The following table gives the results of mechanical
samples of the soil and subsoil of the Scranton sandy loa

Mechanical analyses of Scranton sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.

None of this type is cleared. The virgin forest is chiefly scrub
ne and oak, with considerable huckleberry and bracken. The trees
e stunted, owing, it is believed, to recurring fires. Soil of this kind
generally highly acid, and requires liming for crops other than the
id-tolerant crops, such as potatoes, strawberries, and tomatoes. It
ay have about the same value as the Lakewood soils, but it is not
own just how the hardpan layer affects the growth of crops here.
r successful production of any crop much manure or fertilizer will
needed.

FRENEAU LOAM.

The Freneau loam is a brown to dark-brown loam, about 8 to 10
hes deep, overlying mottled rusty-brown, brown, and black loam,
ich at depths of about 20 to 24 inches is underlain by black or
ttled black, bluish, and greenish loam which is underlain at about
inches by dark bluish green and black sandy loam or by mottled
ish, greenish, and rusty-brown loam, sandy loam, or silt loam.
ere are many variations in color and texture in this soil. Some
the areas mapped consist of Freneau sandy loam and clay loam.
other places the surface soil is a black muck overlying heavy sandy
m, loam, or material of other texture containing varying quantities
glauconitic sand.

This is not an extensive type, and it is unimportant agriculturally.
occupies first bottoms of streams, and the material consists of allu-
m which has been washed mainly from near-by areas of Sassafras
d Collington soils. The drainage is imperfect, and during heavy
ns much of the type is under water. The subsoil is always satu-
ed.

Only a small part of this type is cleared, and very little of this is
med. It is used chiefly as pasture. The native timber growth is
vy with considerable undergrowth. When drained and limed this
e would probably prove a strong soil especially adapted to corn,
othy, and clover.

SWAMP.

The areas classed as Swamp represent various soil materials almost
ot quite continuously in a state of saturation. The material pre-
minating consists of black muck, underlain at depths ranging from
out 15 to 30 inches by whitish sand. Some areas included consist
muck to depths of 2 to 3 feet, and the surface material is brownish
at, as south of the Butler farm on Popes Branch. In the mapping
large areas of this type, especially about the heads of streams and
broad stream bottoms, there are included islandlike areas of
rtsmouth sandy loam, St. Johns sand, and Leon sand.

Swamp occupies a considerable area in all parts of the survey, be-
g especially important in the western half. It occupies large, broad,

$300 to $500 an acre, and some have sold as high
the timber is poor and the land uncleared, $20 to
average value.

Where the land can be economically drained,
tuce, strawberries, and timothy should prove succ

TIDAL MARSH.

A continuous strip of Tidal marsh, ranging fr
mile to 5 miles in width, extends along Barnegat
to Tuckerton on the east, and for many miles up
and other streams. Typically developed, this m
dark-colored, oozy material of silty clay contain
vegetable matter. In the northern part of the are
this salt marsh adjoins areas of Coastal beach,
marsh is found consisting of black sand overlyi
supporting a rather short growth of marsh grasse

Tidal marsh is very extensive, but without va
production of salt hay. The marsh grasses are c
the summer season during periods of low tide or
the ground is frozen. Cut before frost they ma
of hay, which may be fed to horses. The hay ha
of poorer quality and used as packing material,
of glass.

Costly diking and drainage operations, probab
ing, would be necessary to put this character o

The climate is unusually mild considering the latitude. Wint are rarely severe, and the snowfall is usually light. The heat humidity of summer is tempered by the prevailing ocean bree Rainfall is everywhere sufficient for successful farming.

About 20 per cent of the Chatsworth area is cleared and in far the rest is still in forest. Agriculture is restricted to certain p of the area where soils and conditions are most favorable. G grasses, potatoes, and truck crops are among the more import agricultural products. Strawberries, blackberries, and some peac apples, and pears are also cash crops, and the production of c berries is an extensive industry.

Poultry raising is important in the vicinity of Lakewood and T River.

Dairying is carried on extensively in the northeastern and n western parts of the area.

Farms of the Chatsworth area are in general only moderately equipped. Farm practice, however, is modern, and includes rotation, the use of manures and fertilizers, and spraying to co insects and fungous diseases.

The Chatsworth area lies wholly within the Coastal Plain prov and the soils are predominantly sandy and derived from unco dated beds of clay, marl, sand, and gravel. There are represent soil series, including 25 types and 5 phases, and 3 miscellan types.

The Sassafras soils are well drained and very productive. I types, ranging from loam to coarse sand, and 4 phases are ma The loam and sandy loam types are especially strong potato

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